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ORTHOPRAXY.

ORTHOPRAXY:

THE

MECHANICAL TREATMENT

OF

DEFORMITIES, DEBILITIES, AND
DEFICIENCIES

OF

THE HUMAN FRAME.

A MANUAL.

BY

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PREFACE.

In this handbook an attempt has been made to bring together, in a systematic manner, and with reference to a special object, four works, which I have published at different periods.*

Some things have been modified, many added, and all recast, so that the book is not so much a renovation or reproduction as a new work.

The object undertaken is that of claiming for Mechanical Therapeutics recognition as an independent branch of the healing art, and showing, by reference to the gradual but perfected development of mechanical science in its relation to the treatment of deformities, deficiencies, and debilities of the human frame, how just a ground exists for advancing such a claim and for bestowing on this branch a distinctive name.

---

* 'On Artificial Limbs: their Construction and Application.' 1855.

'Localized Movements: or Muscular Exercises, combined with Mechanical Appliances for the Treatment of Spinal Curvature and other Deformities.' 1859.

'On the Mechanical Appliances necessary for the Treatment of Deformities.' 1862.

'Description of a New Artificial Leg invented by Dr. Bly, of America.' 1864.

Nearly a century ago, in this country, Mr. Sheldrake laid the foundation of a new and successful profession, and, by various publications, did his utmost to make known its importance and independent character. My father succeeded him.

Orthopraxy is the legitimate end of their labours, and this book is dedicated to their memory.

H. H. B.

56, Wimpole Street, Cavendish Square, W.;
July, 1865.

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Erratum.—Page 124, "The instrument made use of is depicted in Fig. 32," *read* Fig. 33.

INTRODUCTION.

In the following pages it will be my endeavour to describe the various mechanical appliances which have been found useful for the relief or removal of deformities, certain debilities, and numerous deficiences, both congenital and accidental, of the human frame; also, to treat of the principles which govern the construction of these appliances and their adaptation to the different kinds of deformity, debility, and deficiency which may be alleviated by mechanical assistance: thus making this book a manual of mechanical therapeutics. I venture to claim for mechanics, as applied to therapeutics, recognition as a distinct branch of the art and science of medicine, and feel myself justified in doing so, not only from the large extent to which mechanics are needed, and the not unimportant part which they play in therapeutics, but also from the fact that mechanical therapeutics being now susceptible of reduction to rule and method, they may be rightly regarded as a science as well as an art. Further, I would urge that the practice of mechanical therapeutics is a special craft.

I.—Prior to a knowledge of subcutaneous tenotomy, mechanical means were almost alone available for the treatment of deformities, as they are now the sole method which can be had recourse to for the treatment of many debilities and of all deficiencies. Stromeyer's great discovery and its application to clubfoot, while largely extending the power of the surgeon in relieving deformities, gave an immense impulse to the study of mechanical therapeutics. The increased facilities afforded by the operation for the treatment of many deformities, would have proved to a great extent nugatory, if they had not been accompanied by increased skill and ingenuity in devising the mechanical means necessary to secure its fullest benefits. Moreover, the almost universal adoption of subcutaneous tenotomy, and the consequent greater attention given by surgeons to the relief of deformities was accompanied by a corresponding development of mechanical therapeutics. Subcutaneous tenotomy in one sense limited the field of mechanical therapeutics, as it brought within the sphere of operative surgery many lesions previously held to be amenable alone to mechanical appliances. But in another and juster sense the operation extended the arena of mechanical therapeutics, by giving to them an increased and increasing utility.

The conditions are still numerous where mechanical aid is the sole or principal resource of the physician or surgeon. To enumerate these conditions would be to write a synopsis of the greater portion of this book. It will be sufficient to mention in this place distortions of the spine, hernia, and deficiency of the extremities, whether arising accidentally or from operation.

It cannot now be doubted that the successful treatment of spinal curvature is impossible without mechanical aid. Attempts to invigorate the system, and so indirectly the yielding spine, either by medications or change of climate, or regulated gymnastics; section of the muscles (of all methods of treatment the least rational and justifiable), electricity—each and all will invariably prove useless unless combined with some mechanical appliance for antagonising the tendency to distortion. But when the surgeon or physician is aided by a competent mechanist, the successful treatment of spinal distortions becomes well-nigh a certainty.

Notwithstanding the recent advances made in the radical cure of hernia, it is clear that mechanical support must at all times be the chief method of relief. No question in surgery demands greater thought than the construction of trusses; and no instruments exact more from the skill and ingenuity of the mechanician.

The fabrication and adaptation of artificial limbs are questions which hitherto have been left for solution almost entirely to the mechanist. Mr. Bishop has pointed out that an ill-constructed artificial leg, such as the common wooden leg, is not only a great evil to the wearer by depriving him of the power of quick walking, but also a source of spinal distortion. He insists, therefore, that "surgeons should be familiar with these consequences, more especially as it is too much the custom at our hospitals, as well as in private practice, for them to consider their duty at an end when they have amputated the limb, healed the stump, and directed the patient to an instrument maker. On the contrary," he adds, "a very important duty still remains to be performed, namely, that of promoting the future welfare of the patient by prescribing a proper substitute for the natural limb; and the immense funds subscribed for the support of most of our hospitals might surely afford some allowance to be appropriated for the purpose of supplying poor patients with such improved wooden legs as would enable them to perform all the ordinary occupations of life without difficulty or distortion. This is a subject that army and navy surgeons, more particularly, would do well to take into consideration; since, with the assistance of such a wooden leg, soldiers and sailors might be enabled to discharge most of the common duties of the service, instead of being dependent, as they now are, from the moment they are deprived of a natural leg."* Mr. Teale, of Leeds, has suggested an important modification in the manner of performing amputation, having direct reference to the adaptation of artificial limbs. He recommends a long and short rectangular flap; and commenting upon the methods of operating usually adopted, he says:—"In imputing general *imperfection of*

---

* 'Researches into the Pathology and Treatment of Deformities in the Human Body.' London. 1852. Page 79.

stump to the circular and double flap transfixion methods, I shall perhaps be opposed by most surgeons who have amputated frequently. Each will be ready to say that he is in the habit of making excellent stumps, and, indeed, such was my own feeling in reference to these operations performed by myself. But, when the subject is considered more closely, we may ask ourselves whether a stump is to be regarded perfect merely because it is of seemly form, and not offensive to the sight. We ought further to inquire whether it is adapted to locomotion, by being able to bear a considerable portion of the weight of the body on its end."*

The three illustrations which I have given of the application of mechanics to therapeutics, suggest also certain considerations of the importance of mechanical therapeutics socially, which might be advanced with propriety in support of my argument for their recognition as a distinct branch of the art and science of medicine. To replace a limb by artificial means is to make good a defect which would otherwise render an individual a helpless cripple, a burden to himself, his friends, or the public. To hold in check a hernia by mechanical pressure is to save the ruptured person from contingencies perilous to life, and enable him, else hampered by a continual danger and unfitted for all occupations calling for active exertion, to do the duties of a good citizen in whatever condition of life he may be placed. Deformity, of which distortion of the spine is one of the chief causes, is not only a disability, but it is also a source of much mental suffering. Often deformity unfits a person for the ordinary avocations of life; still oftener it is a constant drawback, embittering existence and shutting out the unfortunate individual from some of the chief enjoyments of society.

---

* 'On Amputation by a Long and Short Rectangular Flap.' London. 1848. Page 2.

When Byron writes of the daring of deformity, and of its striving by heart and soul to overtake mankind and make itself equal, nay, even the superior of the rest, spurred by—

"—— its halt movements to become
All that others cannot, in such things
As still are free to both, to compensate
For stepdame Nature's avarice at first:"*

when, moreover, Lord Bacon (the poet's

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* The 'Deformed Transformed.'

prompter) says, "that whosoever has anything fixed in his person that doth induce contempt, has also a perpetual spur in himself to rescue and deliver himself from scorn; therefore all deformed persons are exceedingly bold;"—both the poet and the philosopher are speaking of those exceptional instances in which congenital deformity has been associated with rare genius. But the spur may impel to degradation as well as to elevation of thought; it may drive the unfortunate deformed to seek refuge from himself and from social neglect or contumely, not in a healthy emulation of what is noblest and best, but in a sad indulgence of that which is vicious and worst. History tells as frequently of infamous as illustrious deformed. Deformity, indeed, as a rule, is a chronic source of discontent and unhappiness, and too commonly it gives occasion to petty insult, annoyance, and neglect.* To relieve deformity is, therefore, to promote the welfare of a community to a very appreciable and not unimportant extent. I have little hesitation in saying, so great is the remedial power which science now has at its command, that the time will come when deformity will be a rare evil among civilised nations. In the census of 1851 for England and Wales, no less than 409,207 individuals were returned as deformed. Of these persons the astounding number of 90,277, nearly one fourth, resided in London. In the face of so great a population of distorted people, the treatment of deformity becomes a social question of no trifling magnitude. Notwithstanding, however, the great prevalence of the evil, my faith in the means which we now possess for contending with it is so firm, that I confidently repeat the assertion that ultimately deformity will become comparatively rare in civilised communities.

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* Passing along Fleet Street shortly after this was written, I saw a little deformed dwarf driven into a state of fury, painful to witness, by the taunts of passing boys.

It will not, I trust, be considered impertinent on my part to remark, that the treatment of deformities has not yet passed into general medical practice. It is still followed almost exclusively as a speciality. This appears to be to a large extent uncalled for. There is no sufficient reason why, in the majority of instances, every practitioner should not undertake the treatment of deformities as of any other lesions which come in the ordinary routine of practice. There is abundant reason why he should adopt such a course. It is in early childhood and youth that the prevention and treatment of deformities to be of the fullest avail should be pursued; hence the necessity for their becoming recognised parts of the general practitioner's duty. I have an impression that the reason why the treatment of deformities is not uniformly carried out by the general practitioner is the want of a trustworthy guide to the mechanical aids necessary for its fulfilment. I am therefore anxious that the present work should serve this purpose. If it should answer this end alone, it will accomplish one of the objects which I have most at heart in its publication.

II. The period when the mechanical treatment of deformities was chiefly a question of brute force is not so remote that the remembrance should have altogether escaped from the minds of the present generation. The time was, and at no distant period, when the surgeon sought to compel a distorted spine or a contracted limb by sheer violence, directly or indirectly applied, to resume its normal position. An inkling of this primitive method is to be found in the more modern practice, now exploded, of constructing instruments for the treatment of spinal curvature upon an ideal type of a symmetrically-formed spine, and exercising force with the intention of causing the curves of the distorted vertebral column to approximate to those of the instrument. Now, however, the mechanist recognises the truth so admirably expressed by the late Prince Consort in one of his addresses, that "in all our operations, it is not we who operate, but the laws of nature which we set in operation." Hence he sets himself diligently to study those laws by which the symmetry of the human frame is maintained, as well as the mode of action of the different causes which lead to a deviation from the normal standard. Apprehending these causes, he seeks to anticipate, or, if too late to prevent, he strives to check the further development of, and to remedy, their evil results. He no longer endeavours to secure his end by a mere empirical use of mechanical force, but by a just adaptation of the means at his command, founded upon a careful appreciation and accurate calculation of the kind, direction, and amount of force required.

The evils of an empirical system of mechanical therapeutics were shown, not only by the in-efficiency or actual unfitness of the instruments fabricated for a given purpose, but also by the imperfection of their construction. They were commonly made either more complex than was necessary, or so simple as to be worthless; so heavy and cumbersome as to weary the body and act as a constant strain upon the muscles, or so light as to yield to the distortion, interposing no impediment to its aggravation. "Lightness" of an instrument is too often sought, even now, at the expense of more important properties. These evils were, and are, the necessary result of an insufficient knowledge of the lesions to be treated. The scientific mechanist constructs his appliances from an accurate estimate of the character and arrangement of the force needed, and of the strength of material required to meet the object he has in view. Hence he avoids on the one hand too great complexity, and on the other a deceptive simplicity, of construction. He economises his material, moreover, in the only manner in which economy can be legitimately carried out, that is, by using so much as may be needed properly to secure the end he would attain and no more. He thus combines the greatest efficiency with the greatest attainable lightness consistent with efficiency; and the indispensable qualities of the mechanism are not sacrificed to a meretricious parade of manipulation and elegance of finish.

III.—Mechanical therapeutics must be practised as a separate craft. Like dentistry, this branch of the healing art needs a special training, and must be followed as an independent pursuit. While it is necessary that the mechanical therapeutist should, on the one hand, undergo a certain amount of surgical education; on the other hand he must be taught the mechanic's handicraft. This latter necessity makes the cultivation of mechanical therapeutics the work of a separate pursuit, distinct not only from surgery, but also from surgical mechanics, commonly so called. At present the work of the mechanical therapeutist is chiefly carried out by, and is looked upon as a legitimate portion of the duties of, the surgical mechanician. Notwithstanding this custom, the many bonds of relationship between the two callings, and the probability that for a long time they will be pursued together, I maintain that mechanical therapeutics should be disassociated from surgical mechanics, in a stricter acceptation of the term.

There is no closer connection between the mechanical skill exercised in the production of the different instruments forming the surgeon's armament and mechanical therapeutics, than between the same skill and the constructive ingenuity of the dentist. The training needed for the surgical instrument maker and cutler differs in many important particulars from that required by the mechanical therapeutist; and it is only by a separation of the two branches of medical mechanics that medical therapeutics will ever obtain that position to which it is entitled.

I do not seek to elevate mechanical therapeutics at the expense of surgical mechanics. I should deeply regret if my observations conveyed this impression. I would protest against any assumption that one field of mechanical art is of greater dignity than the other. I simply hold (whether rightly or wrongly the future will show) that mechanical therapeutics should be practised independently of surgical mechanics, and that the proper cultivation of the former will largely depend upon its emancipation from the latter.

For the reasons which have been thus briefly stated, I claim, then, for mechanical therapeutics recognition as a distinct branch of the art and science of medicine. I venture further, to adopt the term ORTHOPRAXY (ὀρθὸς, straight, right; πράσσειν, to make) as a designation of this branch. The term was suggested several years ago as better calculated to convey the idea of treating deformities by mechanical agency, and as more accurately expressing the wide and widening range of mechanics in therapeutics, than *orthopædy* (ὀρθὸς, straight; παιδῖον, a child). The latter term, moreover, now includes, and practically cannot be separated from, the surgical treatment of deformities. Further, orthopædy is a term which cannot rightly be applied to the restoration of deficiencies, as for example of lost limbs, or the reinforcement of debilities, whether arising from muscular paralysis or from weakness of the tissues, as in hernia. But, both the restoration of deficiencies and the reinforcement of debilities, as well as the relief or removal of deformities, may be included under the term *orthopraxy*, without extending too largely the signification of the word. Indeed the deficiencies and debilities which may be relieved by mechanical means, as they are for the most part directly or indirectly defects of symmetry, might perhaps, be classed as deformities. Orthopraxy is not, perhaps, an euphonious word. It is, however, the least objectionable term which has occurred to me and most closely conveys the meaning which I am desirous to attach to it. It readily admits also of such modifications in its termination and in its adaptation to phraseology which it is desirable that a technical term should possess.

IV.—Orthopraxy is the legitimate culmination of mechanics as applied to therapeutics. Its origin and growth constitute a curious chapter of the history of medicine.

Hippocrates, the "father of medicine," is also the father of mechanical therapeutics. In his Book on *Articulations* he discusses at some length the nature and mechanical treatment of incurvation of the spine and clubfoot. Of his views with regard to the latter deformity, his learned English translator, Dr. Adams, has justly remarked, "it might have been affirmed of him a few years ago, that he was twenty-four centuries in advance of his profession when he stated that in this case there is no dislocation, but merely a declination of the foot; and that in infancy, by means of methodical bandaging, a cure may in most cases be effected without any surgical operation. In a word, until the days of Delpech and Stromeyer, no one entertained ideas so sound and scientific on the nature of this deformity as Hippocrates."*

Hippocrates was fully alive to the pre-eminent importance of mechanical means in the treatment of deformities. When writing of an ancient method of treating distortion of the spine, he particularly remarks, "I give great praise to him who first invented this, and any other mechanical contrivance which is according to nature," &c.

The terms by which Hippocrates designated the different varieties of deformities of the spine are still retained in use by modern authorities. He divided curvatures into (1) gibbosity or the posterior projection; (2) the anterior projection; and (3) the lateral curvature. The first-named deformity he styled *cyphosis;* the second, *lordosis;* and the third, *scoliosis.* Dr. Adams remarks, however, that Hippocrates did not restrict the term *scoliosis* to lateral curvature, but sometimes applied it indiscriminately to the others.

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* 'The Genuine Works of Hippocrates.' Sydenham Society's edition, vol. i, p. 21.

The observations of Hippocrates on the treatment of spinal curvature are of peculiar interest. "When the spine protrudes backwards, in consequence of a fall," he says, "it seldom happens that one succeeds in straightening it." He then refers to a popular method of attempting to straighten the spine, by succussion on a ladder, which would appear to have been in vogue in his days. He states that this method was principally practised by those physicians who sought to astonish the mob—"for to such persons," he adds, "these things appear wonderful; for example, if they see a man suspended or thrown down, or the like; and they always extol such practices, and never give themselves any concern whatever may result from the experiment, whether bad or good." He characterises the physicians who follow such practices, "so far as he has known them," as stupid. The device was an old one, and he gives great praise to the inventor, as well as to the contrivers of many other means of mechanical treatment, in the words I have already quoted. Further he did not despair, that "if succussion were properly gone about, the spine, in certain cases, might be thereby rectified." But, for himself, he was "ashamed to treat all such cases in this way, because such modes of procedure are generally practised by charlatans."

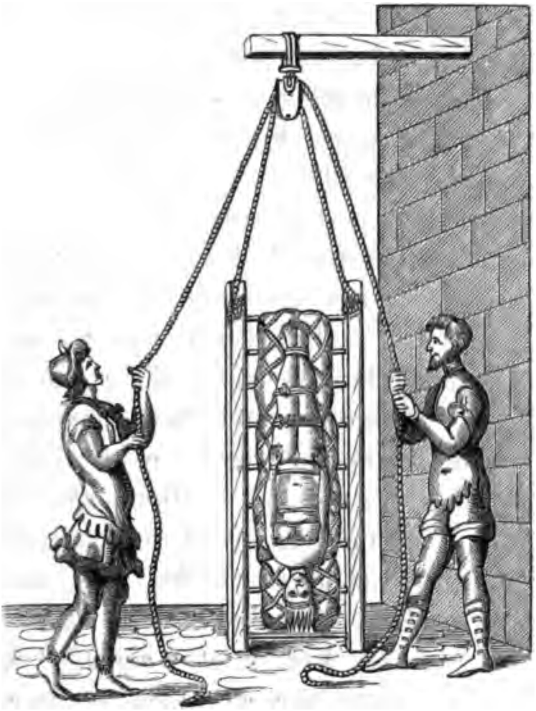
The cases in which succussion is likely to be of service, and the mode of performing the operation are next described.

"Those cases in which the gibbosity is near the neck, are less likely to be benefited by these succussions with the head downwards, for the weight of the head and tops of the shoulders, when allowed to hang down, is but small; and such cases are more likely to be made straight by succussion with the feet hanging down, since the inclination downward is greater in this way. When the hump is lower down, it is more likely in this case that succussion with the head downwards should do good. If one then should think of trying succussion, it may be applied in the following manner. The ladder is to be padded with leather or linen cushions, laid across, and well secured to one another, to a somewhat greater extent, both in length and breadth, than the space which the man's body will occupy; he is then to be laid on the ladder upon his back, and the feet at the ankles, are to be fastened at no great distance from one another, to the ladder, with some firm but soft cord; and he is further to be secured, in like manner, both above and below the knee, and also at the nates; and at the groins and chest, loose shawls are to be put round in such a fashion as not to interfere with the effects of succussion; and his arms are to be fastened along his sides to his own body, and not to the ladder. When you have arranged these matters thus, you must hoist up the ladder, either to a high tower, or to the gable end of a house; but the place where you make the succussion should be firm, and those who perform the extension should be well instructed, so that they may let go their hold equally to the same extent, and suddenly, and that the ladder may neither tumble to the ground on either side, nor they themselves fall forward. But if the ladder be let go from a tower, or the mast of a ship fastened into the ground with its cordage, it will be still better, so that the ropes run upon a pulley or axle-tree. But it is disagreeable even to enlarge upon these matters; and yet by the contrivances now described, the proper succussion may be made."

The following illustration representing the ancient mode of performing succussion is from

Vidus Vidius, in the Venetian edition of Galen's works.

FIG. 1.



If succussion be practised with the feet downwards, Hippocrates urges that care should be taken to fix the head and neck firmly, the trunk and legs being left free, except a loose ligature or two which would keep the latter in a line with the spine, and prevent the trunk swaying out of its place. "These matters," it is said in concluding this part of the subject, "should be thus arranged, if recourse is to be had at all to succussion on a ladder; for it is disgraceful in every art, and more especially in medicine, after much trouble, much display, and much talk, to do no good after all."

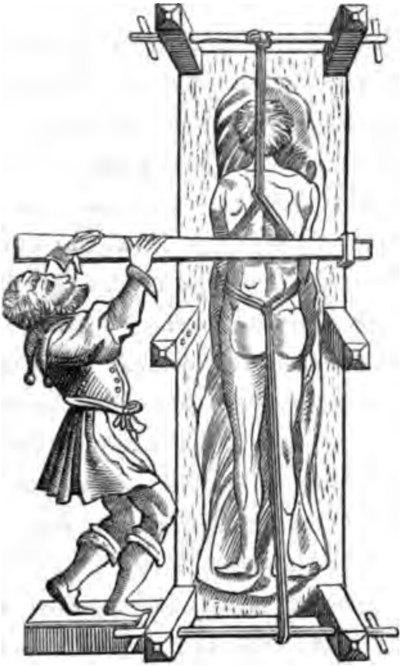
Hippocrates next proceeds to describe "the structure of the spine," which, he says, "should be known, for this knowledge is requisite in many diseases." He then discusses displacements backwards and forwards along the vertebræ, with dislocation, and their hopelessness; and, finally, he details a method of treating gibbosities by extension. A strong and broad board having an oblong furrow in it is fastened to the ground; or in place of the board, an oblong furrow is to be scooped out of a wall, about a cubit above the floor, or at a suitable height. "Then something like an oaken bench, of a quadrangular shape, is to be laid along at a distance from the wall, which will admit of persons to pass round if necessary, and the bench is to be covered with robes, or anything else which is soft, but does not yield much."

The patient after being stoved or bathed with hot water, is to be stretched upon the board on his face, the arms being laid along and bound to his body. Then "the middle of a thong which is soft, sufficiently broad and long, and composed of two cross straps of leather, is to be twice carried along the middle of the patient's breast, as near the armpits as possible, then what is over of the thongs at the armpits is to be carried round the shoulders, and afterwards the ends of the thong are to be fastened to a piece of wood resembling a pestle; they are to be adapted to the length of the bench below the patient, and so that the pestle-like piece of wood resting against this bench may make extension. Another such band is applied above the knees and the ankles, and the ends of the thongs fastened to a similar piece of wood; and another thong, broad, soft, and strong, in the form of a swathe, having breadth and length sufficient, is to be bound tightly round the loins, as near the hips as possible; and then what remains of the swathe-like thong with the ends of the thongs, must be fastened to the piece of wood placed at the patient's feet, and extension in this fashion is to be made upwards and downwards, equally, and at the same time in a straight line. For extension thus made could do no harm, if properly performed, unless one sought to do mischief purposely." The physician is further recommended to press the palm of the hand upon the hump while extension is being made; or a person may sit upon the hump, rising up from time to time, and letting himself fall back upon it. Or a foot may be placed upon the hump and the entire weight of the body brought gradually to bear upon it. Or better still, a lever may be used, one extremity of which is fixed in a hole in the wall, or in the piece of wood fastened in the ground. This lever is to be brought across the hump, a cushion being interposed, and pressed firmly down while extension is made. "These powers are easily regulated" says Hippocrates, "so as to be made stronger or weaker;" and he subsequently says that he is acquainted with no powers which are better and more appropriate than these. He further relates an unsuccessful attempt to treat curvature with a bladder inflated with air.

The following curious cut showing the mode of treating a deformed spine by extension, together with pressure upon the distorted part by means of a lever, is copied from a Latin translation of

'Oribasius et Heliodoro de Machinamentes,' included in a collection of surgical writings published in the sixteenth century.*

FIG. 2.



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* De Chirurgia scriptores optimi quique veteris et recentiores, plerique in Germania antehac non editi nunc primum in unum conjuncti volumen. Tiguri, M.D.L.V. Oribasius et Heliodoro de Machinamentis. Vido Vidio, Florentini Interprete. Ch. xxxv, *De spina luxata.*

A more wonderful chapter is not to be found in all the ancient works on surgery, than that on *Clubfoot,* in the treatise on 'Articulations,' by Hippocrates. In it not only is the nature of the malformation correctly described, but very sensible directions are given for remedying the deformity in early life. The chapter is as follows:

"Wherefore, then, some of these congenital displacements, if to a small extent, may be reduced to their natural condition; and especially those at the ankle-joint. Most cases of congenital clubfoot are remedial unless the declination be very great, or when the affection occurs at an advanced period of youth. The best plan, then, is to treat such cases at as early a period as possible, before the deficiency of the bones of the foot is very great, and before there is any great wasting of the flesh of the leg. There is more than one variety of clubfoot, the most of them being not complete dislocations, but impairments connected with the habitual maintenance of the limb in a certain position. In conducting the treatment, attention must be paid to the following points:—To push back and rectify the bone of the leg at the ankle from without inwards, and to make counter pressure on the bone of the heel in an outward direction, so as to bring it into line, in order that the displaced bones may meet at the middle and side of the foot; and the mass of the toes, with the great toe, are to be inclined inward and retained so; and the parts are to be secured with cerate containing a full proportion of resin, with compresses and soft bandages in sufficient quantity, but not applied too tight, and the turns of the bandages should be in the same direction as the rectifying the foot with the hands so that the foot may appear to incline a little outwards; and a sole made of leather, not very hard, or of lead, is to be bound on, and it is not to be applied to the skin; but when you are about to make the last turns of the bandages, and when it is all bandaged, you must attach the end of one of the bandages that are used to the bandages applied to the inferior part of the foot on the line of the little toe, and then this bandage is to be rolled upwards in what is considered to be a sufficient degree to above the calf of the leg, so that it may remain firm when thus arranged—in a word, as if moulding a wax model, you must bring into their natural position the parts which were abnormally displaced and contracted together, so rectifying them with your hands, and with the bandaging in like manner, as to bring them into their position not by force, but gently, and the bandages are to be stitched so as to suit the position in which the limb is placed, for different modes of the deformity require different positions; and a small shoe made of leather is to be bound on externally to the bandage, having the same shape as the Chian slipper. But there is no necessity for it if the parts be properly adjusted with the hands, properly secured with bandages, and properly disposed of afterwards. This then is the mode of cure, and it neither requires cutting, burning, nor any other complex means, for such cases yield sooner to treatment than one would believe. However, they are to be fairly mastered only by time, and not until the body has grown up in the natural shape; when recourse is had to a shoe, the most suitable are the buskins, which derive their name from being used in travelling through mud; for this sort of shoe does not yield to the foot, but the foot yields to it. A shoe, shaped like the Cretan is also suitable."

Of this remarkable description Dr. Adams has rightly said :*—" Now it appears to me a lamentable reflection, as proving that valuable knowledge, after being discovered may be lost again to the world for many ages, that not only did subsequent authorities, down to a recent period, not add anything to the stock of valuable information which Hippocrates had given on the subject, but the important knowledge which he had revealed to the profession came to be disregarded and lost sight of, so that, until within these last four years, *talipes* was regarded as one of the 'opprobia medicinæ.'"

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* Op. cit., vol. ii, p. 559.

From the time of Hippocrates, about B.C. 500, to the sixteenth century, the history of mechanical therapeutics is a blank. In this vast interval medicine was an extended commentary upon the writings of the father of physic, diversified by fantastic oriental conceptions.

In the sixteenth century, appeared Ambrose Paré's 'Compendious Way of Chirurgery.' Paré was a man of eminent mechanical genius. He, indeed, has drawn in outline an almost entire, although exceedingly crude system of mechanical therapeutics.*

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* The workes of that famous Chirurgion, Ambrose Parey, translated out of Latine, and compared with the French, by

In his chapter on the cure of Ruptures (b. viii, c. xv), writing of those ruptures to which children are subject, he observes that "the chief of the cure consists in folded clothes, and Trusses and Ligatures artificially made." He also relates the "notable history" of a priest who was "cured of a rupture by wearing a truss." Of this case he remarks :—"It is most worthy of observation and admiration that Nature, but a little helped by Art, healeth diseases which are thought incurable." And he adds with singular justness: "The chief of the cure consists in this, that we firmly stay the gut in its place." He illustrates his observations by two drawings, showing the form and adaptation of a single and double truss.

Notwithstanding Paré's apt appreciation of the pre-eminent value of mechanical support in the treatment of ruptures, he supplemented trusses and ligatures with sundry absurd medicinal applications, which form a curious example of the fantastic physic of his day. He advises the use of a complex astringent fomentation and cataplasm

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Thomas Johnson. London: Printed by E. C., and are to be sold by John Clarke, at Mercers Chappell, in Cheapeside, neare y^{e} great Conduit. 1665.

in the case of children; and he also recommends a rupture-plaster of multifarious constituents. He relates also a method of cure made use of, with excellent results, by a certain surgeon "who deserveth credit." This ingenious individual was accustomed to beat loadstone into fine powder, and administer it to ruptured children in pap. He further anointed the rupture with honey, which was afterwards sprinkled freely with iron filings. This treatment was continued ten or twelve days, the rupture, in addition, being bound up with a truss or ligature "as was fitting." The loadstone, it was presumed, "by a natural desire of drawing the Iron, which is strewed upon the groin, joyns to it the fleshy and fatty particles interposed between them, by a certain violent impetuosity, which on every side pressing and bending the looseness of the *Peritoneum*, yea, verily adjoining themselves to it, in process of time by a firm adhesion intercept the passage and falling down of the gut or kall; which may seem no more abhorring from reason than that we behold the Loadstone itself through the thickness of a table, to draw iron after it any way."

The same surgeon was accustomed also to use another form of medicine for the cure of ruptures.

He shut up red snails in an earthen pot, and reduced them to ashes in an oven. The ashes were given to little children in pap, "to those which were bigger," in broth.

The following formula for a Rupture-plaster is from the London Pharmacopœia for 1650.*

Emplastrum ad Herniam.

℞ Galls,
Cypress-cones,
Rind of pomegramates,
Acacia,
Seeds of plantain,
„ housewort,
„ cress,
Acorn-cups,
Parched beans,
Aristolochia (each kind),
Bilberries, āā ℥ss.

Reduce to powder, and soak in vinegar of roses for four days. Roast and dry. Then add of

Comfrey (each kind),
Horsetail,
Woad,
Ceterach,
Root of osmund royal,
„ fern, āā ℥j ;
Frankincense,
Myrrh,

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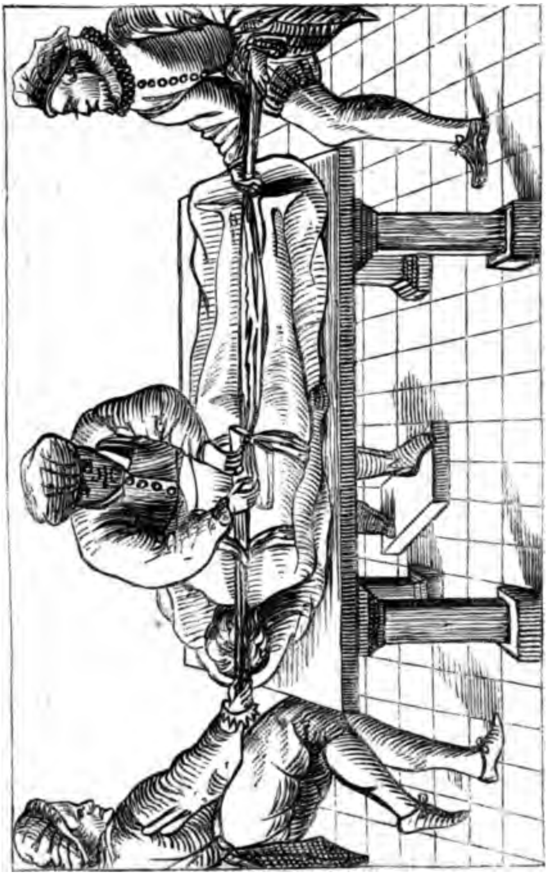
* See the Sydenham Society's edition of the works of Sydenham, vol. i, p. xcvii.

Aloes,
Mastick,
Mummy, āā ℥ij;
Bole armoniac (washed in vinegar),
Calamine,
Litharge of gold,
Dragon's blood, āā ℥iij;
Tar,
Turpentine, ℥vj: or quant. suff.
Fiat emplastrum sec. art.

Paré, in the sixteenth book of his work, devotes seven brief chapters to "luxation of the spine or Back-bone," principally recapitulating the teachings of Hippocrates. In his directions "How to restore the Spine outwardly dislocated" (c. xvi), he varies in no essential particular from his great master. He differs only in setting aside the lever for the purpose of making extension, using direct manual force, and in giving certain instructions for exerting pressure on the projecting portion of the spine. He adds, moreover, directions for the applications of splints to the back when the distortion has been reduced. He teaches that the vertebræ being outwardly dislocated, the patient is to be laid upon a table, with the face downward. (Fig. 3.) Then he is to be bound about with towels under the armpits, and about the flanks and thighs, and by means of these, extension is to be made, but not violently. Unless extension be made, he observes, restitution is not to be hoped

Fig. 3.



for. During the extension, pressure is to be made upon the projecting vertebræ by the hands; but if pressure exerted in this manner fails to restore the protruded parts, then, he writes, "will it be convenient to wrap two pieces of wood, of four fingers long, and one thick, more or less, in linnen clothes, and so to apply one or each side of the dislocated vertebræ, and so with your hands to press them against the bunching forth *vertebræ*, until you force them back into their seats, just after the manner you see it before delineated."

After the vertebræ have been restored to their normal position, he recommends that splints or plates of lead, "neatly made for that purpose," should be bound along each side of the spine, and worn for a long time, the patient being kept on his back in bed.

The twenty-third book of Paré's work is devoted to the means and manner of repairing or supplying the natural or accidental defects or wants in man's body. This book is divided into thirteen chapters. The first chapter is entitled, "How the loss of the natural or true eye may be covered, hidden, or shadowed." Paré prefaces the chapter by stating that, having treated at large in former books of Tumours, Wounds, Ulcers, Fractures, and Luxations, by what means things dissolved and dislocated may be united, things united separated, and superfluities consumed or abated, it remains for him to speak of the fourth office or duty of the Surgeon, which is to supply or repair those things that are wanting by nature, through the default of the first conformation, or afterwards by some mischance. If an eye be lost by mischance or any inflammation, the deformity, he says, may be covered by the following means:—"If that when you have perfectly cured and healed the ulcer, you may put another eye artificially made of gold or silver, counterfeited and enamelled, so that it may seem to have the brightness or gemmy decency of the natural eye, into the place of the eye that is so lost." He gives figures of eyes artificially made showing both the inner and outer side. These eyes are lenticular shields, intended to be placed within the lids and rest upon the injured globe, and they do not differ in any essential respect from those artificial eyes which have been lately brought to such wonderful perfection.

If the patient, from whatever reason, cannot wear the eye so prepared, Paré recommends that a lenticular plate of iron, of the size of the eye when the lids are raised, be covered with leather and painted so as to represent the natural eye. This plate is to be fixed over the defective eye, and retained in its place by a wire, "like unto woman's ear-wires," covered with silk, and passing round the back of the head above the ear. He gives "the figure or portraiture" of this piece of mechanism.

The second chapter shows "by what means a part of the Nose that is cut off may be restored, or how, instead of the nose that is cut off, another counterfeit nose may be fastened or placed in the stead." Paré gives directions for the fabrication of artificial noses, differing little from those found most useful at the present day. The artificial member is to be formed of gold, silver, paper, or linen cloth glued together, and it is to be "so coloured, counterfeited, and made both of fashion, figure, and bigness, that it may as aptly as possible resemble the natural nose." He further instructs that the nose is to be retained in its place by threads or laces passing round the head or attached to the hat. He ingeniously suggests, moreover, that if the upper lip be also damaged the defect should be hidden by attaching a moustache to the artificial nose. He gives figures of both kinds of noses.

The third chapter treats very briefly of the fabrication of artificial teeth.

The fourth chapter is devoted to the "filling of hollowness of the palate." This is to be done, Paré advises, by filling the cavity of the palate with a plate of gold or silver, as thick as a French crown and a little bigger than the cavity itself. On the upper side of the plate a little sponge is to be fastened, which, when moistened "with the moisture distilling from the brain," becomes swollen, and prevents the plate falling down. He gives drawings of artificial palates so prepared, and also figures of another form of palate, on the upper side of which is a button which may be turned by a pair of forceps, called a raven's bill, so as to retain the plate in its proper position.

In the fifth chapter an instrument is described which being placed in the lower part of the mouth will enable those who have lost a part or the whole of the tongue to speak.

The sixth chapter briefly hints in what manner defects of the face, arising from the erosion of pestilent carbuncle, or ulcerated cancer, or deficiency of the lips from wounds, may be hidden.

In the seventh chapter the means for remedying deficiencies of the ears are pointed out, and the fabrication of an artificial ear made of leather or of paper glued together, and carefully painted to represent the natural organ, is described.

Chapter the eighth is entitled "Of amending the deformity of such as are crook-backed." The bodies of many, Paré writes, especially young maids or girls, "by reason that they are more moist and tender than the bodies of boys," are made crooked in process of time, especially by the wrenching aside and crookedness of the back bone. The original vice may be congenital or due to misfortune. But above all, he insists, it is owing "to the unhandsome and indecent situation of their bodies, when they are young and tender, either in carrying, sitting or standing (and especially when they are taught to go to work), saluting, sewing, writing, or in doin any such like thing." Further, Paré writes:—"I may not omit the occasion of crookedness that happens seldom to the country-people, but is much incident to the inhabitants of towns and cities, which is by reason of the straightness and narrowness of the garments that are worn by them, which is occasioned by the folly of mothers, who, while they covet to have their young daughters' bodies so small in the middle as may be possible, pluck and draw their bones awry, and make them crooked."

As a remedy for crookedness of the spine, Paré recommends breastplates of iron pierced with numerous holes to make them lighter, and lined with bombaste so that they may not chafe the body. These plates form apparently a corset in which the patient is to be laced. If the body has not arrived at its full growth, new plates are to be fitted every three months, otherwise "by the daily afflux of matter" the patient would become worse. The plates, he adds, will do much good to persons already of full growth. He appends figures of the plates which are copied in the following woodcuts. (Figs. 4, 5.)

Paré's corset is the earliest piece of mechanism intended to be worn for the relief of a distorted spine, with which I am acquainted.

In chapter the ninth is described certain mechanical aids not included in the arrangement of the present work.

Chapter the tenth shows "by what means the perished function or action of a thumb or finger may be corrected and amended," and a figure is

FIG. 4.

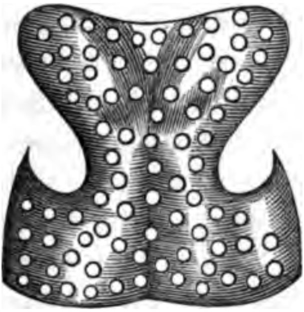
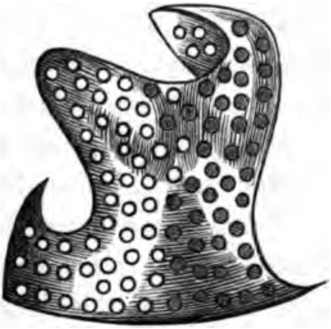


FIG. 5.



given of "the form of a thumb- or finger-stall of Iron or Laten to lift up or erect the thumb, or any other finger that cannot be erected of itself." An "erector of the hand" is also figured.

The eleventh chapter is headed "Of helping those that are *Vari* or *Valgi*, that is, crook-legged or crook-footed, inwards or outwards."

Vari, Paré says, are those whose feet are bowed or crooked inwards. This deformity is congenital, or else it arises because the child's legs have not been sufficiently well swathed in the cradle, or because it has been carried carelessly or not well looked after by the nurse when learning to walk. *Valgi* are those whose legs are crooked or bowed outwards. This deformity arises from like causes as the former. In both varus and valgus the bones are to be thrust into their normal position and retained there, otherwise they not being well established would slip back again. "They must be staid in their places," writes Paré, "by applying collars, bolsters on that side whereunto the bones do lean and incline themselves; for the same purpose boots may be made of leather of the thickness of a testone, having a slit in the former part all along the bone of the leg and also under the sole of the foot, that being drawn together on both sides they may be better fitted and sit close to the leg. And let this medicine following be applied all about the leg—℞ Thuris Mastich., Aloes, Boli Armeni, ana, ℥j; Aluminis roch resinæ pini siccæ, subtilissime pulveris, an., ʒiij; Farinæ Volat., ℥jiss; Album. Ovor. q. s., make thereof a medicine. You may also add a little turpentine, lest it should dry sooner or more vehemently than is necessary. But you must beware and take great heed lest that such as were of late *varous* or *valgous* should attempt to strain themselves to go before that their joints be confirmed, for so the bones that were lately set in their places may slip aside again. And, moreover, until they are able to go without danger let them wear high shoes tied close to their feet that the bones may be stayed the better and more firmly in their places, but let that side of the sole of the shoe be underlayed, whither the foot did incline before it was restored."

Paré adds two drawings of "The form of little boots," whereof the one is open and the other shut.

Chapter the twelfth shows, "By what means Arms, Legs, and Hands, may be made by art, and placed instead of the natural Arms, Legs, or Hands that are cut off and lost." The following illustrations are copies of Paré's curious drawings of "an Hand made artificially of iron," and of "the form of an Arm made of iron verie artificially." These pieces of mechanism, together

Fig. 6.

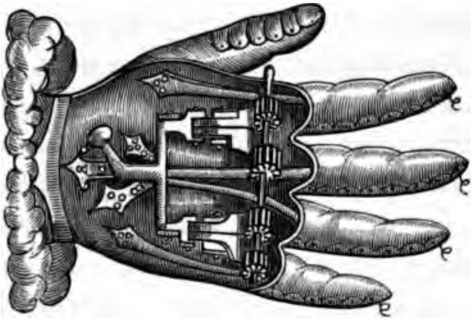
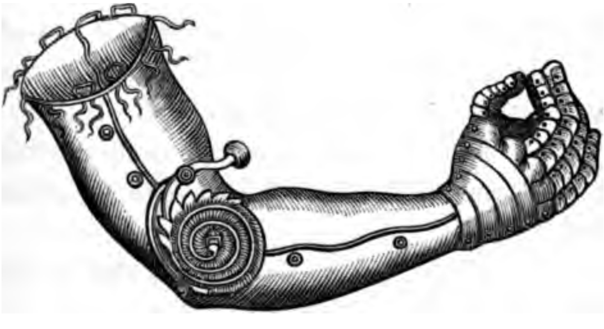


Fig. 7.



with certain elaborate artificial legs, were made for Paré, "to his great cost and charges," by "a most ingenious and excellent Smith dwelling at *Paris*, who is called of those who know him, and also of strangers, by no other name than the little Lorain." With thoughtful care for the impoverished, Paré gives a drawing of "a wooden leg made for a poor man." This leg is the common and efficient wooden leg, with bucket receptacle, still in use.

Chapter the thirteenth is "of amending or helping lameness or halting," and contains a description and figures of an elaborate crutch, with a rest for the foot and cross-bar, which supports the thigh, forming a kind of seat for the patient.

Well-nigh five centuries elapsed before the important position which Paré assigned to mechanics in therapeutics was secured in practice. The mechanical ingenuity of the fourteenth and four succeeding centuries failed to give that development to his suggestions of which they have, in the present century, proved susceptible.

Early in the seventeenth century Fabricius Hildanus* adapted the screw to straightening contracted joints. He made use of two splints joined together at one extremity by a hinge. The splints formed an angle, across which, near the middle, extended a screw, by the aid of which the angle could be enlarged. This piece of mechanism closely resembles Liston's or Amesbury's splints. He also describes a method of treating contraction of the knee by means of a straight iron splint fitted to the back of the limb. About the middle of the splint is a screw to which is attached a ring which encircles the knee. A pad is interposed between the knee and the patella, and by turning the screw the joint is drawn backwards towards its normal position. Hildanus describes, moreover, a method of curing by mechanical means contraction of the fingers, arising from burns.

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* 'Observationum et Curationum Medico-chirurgicarum centauria,' 1630.

In 1656 Scultetus figured sundry splints for the treatment of crooked limbs. He also describes an apparatus for extending a distorted spine, and subjecting the protruded portion to pressure by a lever. This mechanism was termed the Torquen, and it does not differ essentially from that drawn by Oribasius, of which a copy has been given in a previous page; but extension is made from the head of the patient.

In the middle of the seventeenth century a method was in use of treating children suffering from distorted spine by suspension, so that extension was produced by the weight of the body, occasionally augmented by heavy substances attached to the feet. Splints of whalebone were also made use of for straightening the crooked back. Glisson* directs that the child be cunningly suspended by "swathing Bands, first crossing the Breast, and coming under the Armpits, then about the Head and under the Chin, and receiving the hands by two handles, so that it is a pleasure to see the Child hanging pendulous in the air, and moved to and fro by the Spectators. Some," he adds, "that the parts may the more be stretched, hang Leaded Shoes upon the Feet, and fasten weights to the Body that the parts may the more easily be extended to an equal length." He further writes: "To straighten the trunk of the Body or to keep it straight they used to make Breast-plates of Whalebone put into two woolen Cloaths and Sewed together, which they so fit to the Bodies of the Children that they may keep the Backbone upright, repress the sticking out of the Bones and defend the crookedness of them from a further compression. But you must be careful that they be not troublesome to the children that wear them, and therefore the best way is to fasten them to the Spine of the Back with a handsome string fitted to that use."

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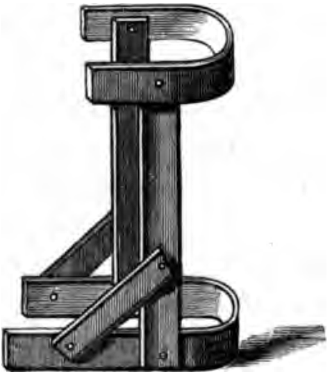
* 'De Rachidite,' translated by N. Culpepper, 1651.

About the same period Arcæus described a cumbersome apparatus for reducing clubfoot* and keeping the restored foot in situ. The following is a drawing of the apparatus made use of by Arcæus.

FIG. 8.



It is instructive to compare this apparatus with one which I have recently had occasion to fabricate for a case of equine varus (Fig. 9). The principles which govern the construction are the same; the mechanical ingenuity with which they are carried out, the addition of a lateral joint, and the substitution of a lateral lever in place of an unbending arm alone differ.

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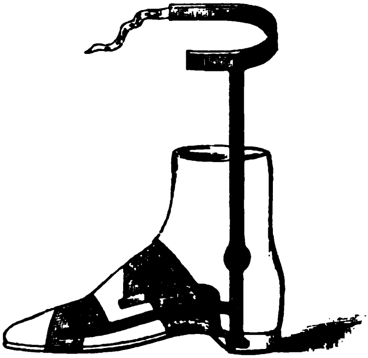
* 'De Curandis Vulneribrus,' 1658.

FIG. 9.



Later in the fifteenth century, Isaac Mincius divided the sterno-cleido mastoid muscle for the cure of wry-neck. Nearly two centuries passed before the true value of this operation was appreciated.

Early in the 18th century Heister* made use of a T-shaped splint of thin steel for the treatment of spinal curvature. This splint was fixed in its place by neck, shoulder, and pelvic straps.

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* 'Chirurgie,' 1739.

About the middle of the same century appeared M. Andry's work on *Orthopædy*, which initiated a new epoch in the treatment of deformities.

At this period almost all the mechanical appliances which have since been found useful in therapeutics had been made use of by physicians and surgeons, although in a crude and unsatisfactory form, and with very indifferent success. They were based almost solely upon an empirical knowledge, and they were constructed in the rudest fashion. The mechanical treatment of distortion of the spine was little in advance of that described by Hippocrates; and the treatment of club-foot was less advanced. Glisson's corset of whalebone was pretty much on a par for utility with Paré's breastplate of iron. Of Heister's cross-shaped spinal splint a learned writer has justly said that "it is a fair type of many such contrivances, very ingenious as far as mechanical idea is concerned; yet a patient who could wear this cross must be tolerably straight, for if very crooked he would infallibly be strangled."*

Mechanical extension was the chief method in use for the treatment of spinal curvature. Mechanical supports had been devised for the same object. Sundry forms of splints existed for the treatment, in conjunction with bandaging, of deformities of the limbs; and the screw had been ingeniously applied to extend contracted joints. Mechanical shoes were also in use for the removal or relief of club-foot. If an eye were lost, it could be imitated; if the ear were defective, the defect might be hidden; if the nose were wanting, an artificial one was forthcoming; if a limb were lost, a substitute could be procured; and if the walls of the body failed in any part, means were not wanting to strengthen them. But the crudity of conception was such, as well as the rudeness of construction, at the time when Andry wrote, as to induce little confidence in the mechanical treatment of deformities.

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* See an elaborate article "On the Treatment of Deformities," in the 'British Medical and Chirurgical Review' for October, 1861. I would acknowledge the valuable assistance I have derived from that article in writing this portion of my work.

The publication of M. Andry's work was the commencement of that systematic study of deformities which rendered a scientific application of mechanics to therapeutics, such as now exists, possible. This work, which appeared in 1741, is entitled: '*L'Orthopédie; ou, l'Art de prévenir et de corriger dans les Enfans les Difformités du Corps le tout par des moyens à la portée des Pères et des Mères, et de toutes les Personnes qui ont des Enfants à élever. Par M. Andry, Conseiller du Roy, Docteur et Professeur en Médecine au Collège Royal, Docteur Régent et ancien Doyen de la Faculté de Médecine de Paris*, &c.' It is in two volumes, small 8vo, illustrated with copper-plates, and there is an appendix, forming a third volume. The author tells us that he has formed the term *Orthopædia,* then for the first time used, "from two Greek words, namely, from *Orthos,* which signifies straight, free of deformity, according to rule, and from *Paidion,* which means child. I have composed from these two words," he adds, "that of Orthopédie, to express in a single term the plan of this work, which is to teach different methods of preventing and correcting the bodily deformities of children." The term has been commonly adopted, but it is frequently used with a more extensive signification, embracing the correction and prevention of deformities at all ages.

The mechanical treatment of deformities occupies an insignificant portion of M. Andry's work. He recommends a chin-rest for stooping of the head.* For crooked legs he advises an iron splint, and states that the same means must be taken to straighten them as are adopted to straighten the crooked stem of a young tree.† He illustrates this statement by a drawing of a distorted tree, which is sought to be redressed by being firmly bound to a straight post placed on the side of the concavity. Deformed feet, he says, are to be remedied by splints of strong card-board or wood, or little plates of iron. These he considers to be better than the boots usually employed in such cases. For the rest, attention is chiefly given to inunctions and frictions of deformed parts, and their gradual restoration by manual extension, pressure, and localized movements. In these respects the book may be read with profit even at the present day. But the work is in an especial manner devoted to those deformities which result from evil and awkward habits engendered in childhood, or from the careless or inconsiderate handling of nurses. He gives many ingenious directions for the avoidance of all things tending to induce an ungainly carriage, recommending certain exercises, as for example, carrying a stick with wide-spread arms, to extend the clavicles; bearing a weight upon the head, when it tends improperly to one side; or upon the shoulder, if one is higher than the other. The work, indeed, in many points is one, as Mr. Turveytop would have said, of deportment. It includes, indeed, much that would offend the dignity of the orthopædic practitioner of the present day.

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* Vol. i, p. 90.

† Vol. i, p. 282.

The first book contains a general account of the exterior of the body. The second discusses the means of preventing and correcting in infancy deformities of the carriage. Writing of high-heeled shoes, which have once more become the fashion among us, Andry points out that they cause young persons to stoop, and ought not to be worn by girls until they are fifteen years old. The third book deals with deformities of the arms, the hands, the legs, and the feet. He describes and details the characteristics of well-made arms, hands, and fingers; and he touches specially upon the following deformities of the hand and fingers: (1) Rough, hairy, and crooked hands; (2) Hooked hands; (3) Swelling of the vessels of the hand; (4) Warty hands; (5) Callosities of the hands; (6) Trembling of the hands; (7) Tetter of the hands and arms; (8) Sweaty hands; (9) Tailor's thumb; (10) Warped fingers; (11) Supernumerary fingers; (12) Chilblains of the fingers; (13) Shoulder of mutton hand; (14) Itch of the hands and arms; (15) Deformities of the nails: (*a*) nails ragged at the root; (*b*) hooked nails; (*c*) too short nails; (*d*) deciduous and ass-backed nails; (*e*) knotty nails; (*f*) spotted nails; (*g*) split-nails; (*h*) livid nails; (16) The left-handed.

The fourth book is devoted to deformities of the head, and is followed by a chapter on the voice. The appendix, forming the third volume, contains an answer to certain criticisms upon the work.

A quarter of a century after the publication of Andry's work, the treatment of club-foot obtained great notoriety in England, France, and Switzerland, through the labours of certain men who largely advertised a cure for the deformity by means which were kept secret. The most celebrated of these charlatans were Tiphaisne, of Paris, and Venel, of Canton Berne. Tiphaisne appears to have been an ingenious mechanist. Venel was a medical man of humane character, who had ultimately purposed, it is believed, to have purged his reputation of the unprofessional taint which attached to it from his having voluntarily placed himself in the category of quacks; but death cut him off before he carried his good intentions into effect. He established an institution for the cure of club-foot, and his successes excited considerable attention in Germany. From a former patient a tolerably correct idea of Venel's method of treatment, and the mechanical means he used, was obtained by Dr. Ehremann. The latter had an imitation of Venel's apparatus fabricated in iron. This was seen and copied by Brückner, of Gotha, and Naumburg of Erfurt. Naumburg* published the results he had obtained with Venel's machine in 1796, and Brückner,† in 1798. The machine and its application have been thus described:—"The foot was fastened in a leather buskin with a strap attached; then while thus covered it was placed in an iron box, and the strap assisted in holding the limb immovable. The iron box or shoe is a very complicated apparatus with a staff or lever to run up the leg, and is composed of movable plates, screws, &c., which gradually squeeze the part into a normal shape, while the staff, turning the foot on its long axis, causes the sole to face directly downwards instead of inwards. One great feature of the treatment was the slowness with which it was commenced, the machine being at first applied only for an hour, and with very little tension daily; then both time and force were gradually increased until the child could bear its application during the night. It generally took two years to complete the cure either by this method or that of Tiphaisne."*

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* 'Abhandlung über Verkrümmungen.'

† 'Ueber einwärts gedrehte Füsse.'

Tiphaisne's name is intimately associated with the invention of Scarpa's well-known shoe for the treatment of club-foot. The story goes, that Scarpa, in 1781, during a residence in Paris, chanced to pass Tiphaisne's house. His attention was attracted by sundry paintings of deformed feet suspended about the door. He learned that these were drawings of children's feet which Tiphaisne asserted that he had perfectly cured. Scarpa sought Tiphaisne's acquaintance, but he failed to obtain from him any knowledge of his method of treatment, except on one occasion when Tiphaisne made the oracular observation: "Nature will not yield to violence, but only to gradual force." Being foiled in gathering the information he wanted by fair means, Scarpa discreditably had recourse to foul. He bribed Tiphaisne's housekeeper, and, during the absence of her master, obtained admission to his private room. There he found nothing to satisfy his desires but a steel spring lying on a cushion. This fragment of an apparatus, however, prompted the Italian anatomist's ingenuity, and after a few experiments on spring-power, he devised the shoe which bears his name, and which was described by him in his Monograph, 'Sulle Piedi Torti,' published in 1803.*

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* 'Brit. and For. Med.-Chir. Rev.,' Oct., 1861.

The style of dress worn by ladies at the close of the 18th century gave a great impulse, particularly in France, to the treatment of deformities generally. It was so scanty, and clung so closely to the figure, as to render apparent any defect in the trunk or legs. Hence a rage arose for deformity curers.

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* This story is told by Malfatti, in a preface to his German translation of Scarpa's Monograph.

The popular feeling facilitated that more accurate and systematic study of deformities inaugurated by Andry.

In 1768, M. le Vacher made public, in the fourth volume of the 'Memoirs de l'Academie Royale de Chirurgie de Paris,' an apparatus for supporting the head and gradually extending the spine in cases of curvature. The apparatus is carried by a strong well-fitting corset. A stout, perpendicular, movable iron rod, fixed to a socket behind, ascends to the occiput. From the upper extremity an arch springs, which passes over the summit of the head and nearly touches the forehead. From this arch is suspended a bow of polished steel, which hangs over the head from ear to ear, and carries chin and occipital straps. When the instrument is adjusted the head is held erect, and the perpendicular rod can be elevated or lowered by means of a ratchet and spring.

Subsequently the writings of Pott* in England, and of David,† of Rouen, in France, placed the knowledge of the pathology of spinal curvature on a much more satisfactory basis.

In 1794, Schmidt, of Marburg, constructed an instrument for the treatment of spinal curvature, by means of which the whole weight of the upper part of the trunk was supported. This instrument closely approaches the type, and is fabricated essentially on the same principles upon which all succeeding instruments for the effective relief of this deformity have been formed. A metal band encircles the pelvis, resting upon the *crista ilii.* This band carries two metal rods, which pass up one on each side of the body, and terminate in crutch handles beneath the armpits. The rods are joined together at the upper extremity, and steadied by a plate which passes across the shoulders.

In the same year Mr. Sheldrake published his work entitled '*Observations on the Causes of the*

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* 'Remarks on that kind of Palsy of the Lower Limbs which is frequently found to accompany a Curvature of the Spine,' 1779.

† 'Leçons Clinique sur les Maladies de l'Appareil Locomoteur,' 1779.

Distortions of the Legs of Children, and the Consequences of the Pernicious Means generally used with the intention of Curing them.' He discussed the defective principles upon which instruments for the treatment of deformities were constructed and their frequent misapplication. Admitting that they were framed upon principles not altogether inapplicable to the diseases they were intended to cure, he pointed out that they were inadequate for the purpose, and that not one patient in twenty upon whom they were applied in the common way derived any benefit from the use of them. He animadverted strongly upon the weight and cumbersomeness of the instruments in common use, and the difficulty of movement among children to whom they had been applied. He further introduced the lever into practice, and writing of the instrument he constructed for the treatment of club-foot, he says, "The idea upon which this method is founded is to substitute a spring so adapted to the nature of the distortion, that when bound upon the limb its action will draw the deformed parts into their natural situation when it is necessary to allow of motion in the limb; that motion, by increasing the action of the spring, accelerates the cure."

In 1796, Dr. Darwin* showed the value of recumbency in the treatment of spinal curvature; and he recommended a chair to which was attached a head swing somewhat after the fashion of Le Vacher's, and crutches upon the principle of Schmidt's instruments.

In 1801, the professional estimate of the treatment of deformities was summed up in the following words by Benjamin Bell:† "It has been a prevailing opinion among practitioners, that little advantage is to be derived from any remedies that we can employ for distorted limbs, and they have seldom made any attempt to cure them. In consequence of which, this branch of practice has been almost universally trusted to itinerants or to professed bone-setters. In this, however, we are wrong; in saying so, I can speak with confidence, founded on much experience, having early in life observed the misery to which patients were reduced. I was resolved to make some attempts for the relief of such as might apply to me, however small the chance might be of succeeding; and in various instances I have had the satisfaction of relieving, and in some cases of curing completely, patients who had been lame for several years, and where it was not expected that anything could be done for their advantage. * * * * Various machines have been invented for the removal of distortions of the spine by pressure. All of these, however, do harm, and ought not to be used. It must at once appear to whoever is acquainted with the anatomy of these parts, and with the nature of this disease, that the displaced bone is never to be forcibly pushed into its situation; and if this cannot be done, it is obvious that no advantage is to be derived from the practice, while it is evident that much harm may ensue from it. In all distortions of the spine it is an object of the first importance to support the head and shoulders. If this is neglected, the weight of the head tends almost constantly to increase the curvature."

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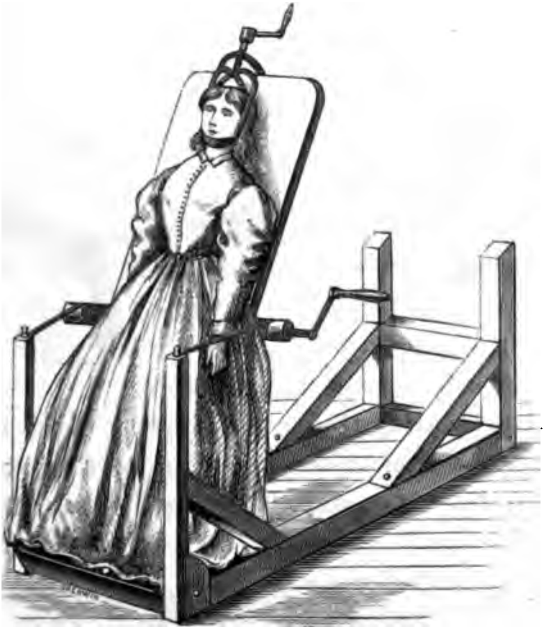
* 'Zoonomia,' vol. ii, p. 87.

† 'A System of Surgery,' 7th edition, vol. vii, p. 197 and p. 213.

At the time when Bell wrote, Schmidt had shown the true principle upon which the upper part of the trunk was to be supported in spinal curvature; Sheldrake had pointed out the error of too great weight in the construction of instruments, and the importance of their being so fabricated as to interfere in the least degree with locomotion. He had, moreover, introduced the use of the lever in the treatment of distortion. The screw had long before been adopted in treatment. Every other form of mechanical apparatus for the amelioration of deformities in a more or less crude form was also in use. The great principles of mechanical therapeutics had, indeed, been laid down, but another half century was required for their elaboration and systemisation.

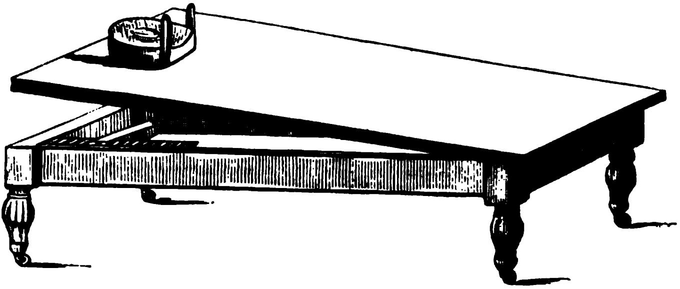
Men throw aside the influence of tradition with difficulty, and even at the dawn of a true science of mechanical therapeutics we find a reproduction of some of the rudest efforts of more primitive times. For example, Sheldrake revived the practice of suspension, divested, however, of the roughness of a more remote period. He conjoined suspension with recumbency. He invented an apparatus consisting of a frame so constructed that the surface on which the patient reclined could by means of a winch and pully be raised into a vertical position. Whilst in this state, the patient's head was secured to the apparatus by a strap passing under the occiput and another under the chin. These two straps were next secured to an arched piece of metal fixed to the upper margin of the reclining surface, and this curved piece of metal was then wound up until the patient's neck and spine were stretched to such an extent as to place the body on tip-toes. When this was done, the inclined surface was lowered to an angle of 25°, and the patient left for the night. (Fig. 10.) During the day a spinal support, somewhat after the fashion of Schmidt's, was fitted to the patient.

FIG. 10.



Early in the present century, Dr. L. Harrison revived the ancient treatment of spinal curvature by violent extensions, suspension by pullies, and severe pressure on the protruding part. He also made use of a passive means of extension by the aid of an inclined couch. (Fig. 11.) The patient was laid on the back, and the head fixed in a padded receptacle, like a horse's collar. The couch was then raised to an angle of 25°, the whole weight of the body in this position dragging upon the head.

Fig. 11.



I have briefly sketched the history of the mechanical treatment of deformities to the period when the main principles of mechanical therapeutics had been worked out. To follow the development of these principles, and the growth of a scientific system of mechanical therapeutics in the past half century would require space equal to that of the entire book. The facts of greatest interest in reference to the perfection of certain instruments and forms of apparatus will be given in the body of the work in their proper place. The book itself will show the completed results of the half century's labours.

Mechanical therapeutics has advanced *pari passu* with surgical pathology. In 1834, a vast impulse was given to the treatment of certain deformities by Stromeyer's introduction of the practice of subcutaneous tenotomy. Two centuries had passed before the idea of Mincius bore fruit. Sartorius (1806) and Delpech (1816), had made abortive attempts in the same direction. In 1837, Dr. Little introduced Stromeyer's practice into London, and the Orthopædic Hospital was established; and in 1843 he published his work on the '*Nature and Treatment of Club-foot, and analogous Distortions with and without surgical operation.*' In the same and following year Dr. Little's classical lectures, since published in a separate form, on the '*Nature and Treatment of the Deformities of the Human Frame,*' appeared in the '*Lancet.*'

To the writings of this gentleman and of Mr. John Bishop, F.R.S., it is chiefly due that the knowledge of deformities in this country was placed on a sound basis. As this knowledge advanced so also did mechanical therapeutics, and the latter now claims recognition as a distinct branch of the art and science of medicine,—with what justice the following pages must show.[*]

V. It is an easier task to restore the symmetry of a distorted limb or spine by the employment of mechanism, and, where needed, of tenotomy, than to reinvigorate a muscle wasted by disease. The latter object can be satisfactorily achieved only by *systematic exercise of the debilitated muscle.* Thus the gymnasium becomes a necessary ally to the treatment of deformities, and gymnastics hold an important position in mechanical therapeutics.

In almost all large continental cities the treatment of deformities by a combination of well-directed muscular exercises with skilfully adapted mechanism has so long been pursued as to have become a customary arrangement. In Vienna, Berlin, Stuttgard, Dresden, Munich, &c., special institutions are established for the purpose of carrying out in the most perfect form the principles and practice of this method.

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[*] See page 5.

In England the utility, nay, necessity of gymnastics in the treatment of deformities has not received that full recognition which is desirable, but a livelier interest has lately been aroused on the subject. Gymnastics are alone required for the relief of the slighter kinds of deformity of the spine and limbs; and the graver degrees of distortion may be much ameliorated by their aid. The special gymnastics for different deformities will therefore be detailed in the following pages.

Gymnastics, moreover, are the chief means which we possess for the prevention of deformities.

When the human race is advancing in the scale of civilisation in the rapid manner so characteristic of the present time, a greater degree of physical strength is needed, if we would escape degeneration, to encounter the severe bodily strain induced by the over-tension (so to speak) of life. Let any one who questions the danger of a future degeneracy of race under present arrangements visit a fashionable English boarding-school, and, in the delicate features of the majority of the pupils, he will see how little chance there is for the cultivation of that healthy bodily vigour which is necessary for the propagation of a powerful people.

Latterly, the habit of restraining all exhibition of playful gaiety, under the impression that it betrays vulgarity of manner, has been attended with the most serious consequences to the physical development of the rising generation. I firmly believe that the enormous increase in spinal curvature which has taken place during the last twenty years may be traced much more to the imprudence of forbidding "romps," and other robust exercises of "childhood taking holiday," than to any supposititious diminution in the constitutional power of mankind. What is needed for the purpose of counteracting this serious and growing evil, is to insist upon the adoption of regulated gymnastic movements during a certain period of the day, accompanied, as far as practicable, with free and unrestrained bodily exercise. This especially refers to those persons who are *healthy;* but where debility of constitution exists, a systematic course of "movements" should be adopted without loss of time. In order to accomplish this object in a manner certain to produce the desired result, it is necessary that all the muscles of the body should be gradually brought into gentle exercise. It might be considered that walking, riding, or the ordinary actions of daily life, would be sufficient for the purpose; but such is not the case, and for this reason, that from lassitude all the general exercises dependent upon voluntary activity are imperfectly performed. The superintendence of the *gymnasiarch* is needed to produce such an amount of well-regulated motion in each set or system of muscles that the body may be *gradually* improved in strength.

A national pride is felt in the stalwart proportions and manly symmetry exhibited in the persons of our "Household Troops." Knowing that they are but the trained and well-cultivated representatives of the physical stamina abundantly to be found in all our rural districts, it appears surprising that we have done so little systematically to improve the muscular development of our youth, and to cherish and strengthen those thews and sinews which in due time will be called upon to bear the attrition and turmoil of our modern go-ahead life.

In former ages, the tilting and the wrestling-grounds furnished ample exercise for the physical powers both of the noble and the serf; but now-a-days the head usurps the place of the arm, and an enfeebled condition of the body is too often the penalty attached to a highly cultivated mind.

If defective physical were at all times accompanied by a higher degree of intellectual activity, it might be argued that the loss in one direction was more than counterbalanced by the gain in another. But this is not the case, and it too often happens, where the deficiency is a sign of deterioration of race, that the mind suffers equally with the body. Healthy activity of body and mind are as a rule correlative.

Nature, we learn from the wise and beneficent laws of human organization, has clearly decreed that, unless the various parts of her handiwork intended for special aims and uses are regularly made to fulfil their destined purposes, an entire perversion of her original plans is entailed, that which ought to be a strong and vigorous frame becoming a weak and emaciated machine, defective alike in power and symmetry. Man not only improves and perpetuates the ethnological and physiological advantages which are gained by the mingling of races, but he also increases and perpetuates any organic and physical defects which are established by non-adherence to the conditions implied in the adaptability of the different parts of the human frame to their several uses. How readily do we discover the inevitable results which ensue from the possession of a Sybaritic form, when contemplated as the type of a people.

The ancient Greeks and Romans, when the habits of the bath and attendance at the theatre superseded the exercises of the chariot-ring and the cestus, rapidly became the inferiors of neighbouring populations, to whom luxurious living and corrupt and enervating pastimes were as much matters of abhorrence as the nations which found leisure in them were the objects of their disgust and hatred.

To avert any approach to the degeneracy of form and character, such as is well known to have reduced the once masculine energy of the Roman people to the state of indolence and inactivity exhibited by their descendants of our own times, a judicious course of gymnastics for our youth is earnestly to be desired. Such a course is especially needed to prevent the more immediate danger of deformity.

I do not think that any reasonable doubt can be entertained that a great number of those cases of malformation and distortion which are so painful to our eyes, and mortifying to our pride, are largely owing to an absence of physical culture on the part of the deformed individuals.

As a means of guarding against and preventing the origin and perpetuation of these evils, it is to be hoped that well-regulated bodily exercises will be more largely cultivated.

The great Volunteer movement may be looked upon as a vast gymnastic training of the youth of the nation ; and in this sense alone its value cannot well be over-estimated.

THE
MECHANICAL TREATMENT
OF
DEFORMITIES, DEBILITIES,
AND
DEFICIENCIES OF THE HUMAN FRAME.

CHAPTER I.

THE HEAD AND NECK, THEIR DEFORMITIES, DEBILITIES, AND DEFICIENCIES.

I.—Deformities.

The head and neck, although liable to many defects of symmetry, are less subject to deformity than the trunk and extremities. This is remarkable when the nicety with which the skull is poised upon the spinal column, the number and complex arrangement of the muscles attached to it and to the cervical vertebræ, and the great flexibility of the upper segment of the spine, are considered. Several causes may be indicated as probably giving rise to this comparative freedom from distortion. First, the weight supported by the cervical vertebræ is not great. This important source of spinal deflection in the dorsal region, when the ligaments are weakened, and the intervertebral substances or the vertebræ themselves affected by disease, is diminished to the greatest extent in the cervical region. Again, the muscles of the neck, as those of the trunk, are less liable to permanent contraction than the muscles of the extremities. It is probable, moreover, that spastic contraction of the muscles of the neck, as a rule, gives rise to a less degree of deformity than the same condition of the muscles of the extremities. It would seem, indeed, as if the degree of deformity arising from permanent contraction of a muscle was less dependent upon the situation of the muscle than upon its bulk and length. For example, the longest muscle connecting the head with the thorax, and entering more largely than any other muscle into the different movements of the neck, is the sterno-cleido mastoideus. The space over which this muscle acts is much less than that over which either the tibialis anticus or gastrocnemius acts; and the degree of deformity arising from spasmodic contraction of the first-named muscle is proportionally less than that which arises from morbid contraction of either of the last-named muscles. Spasmodic action of the sterno-cleido mastoideus, unless excessive, rarely produces very marked deflection of the skull; but slight spastic contraction of the tibialis anticus or gastrocnemius gives rise to considerable deformity of the foot. This difference of result is to be accounted for (1) by the difference in the amount of force exercised by the several muscles upon their points of insertion and attachment; and (2) by their different ranges of action. Thus the retractile power of the tibialis anticus, in its course from the upper third of the tibia and fibula to the os scaphoides, extends over a space of fourteen inches; but the retractile power of the sterno-cleido mastoideus is limited to a space of five inches. Again, the bulk of the contractile tissue of the former muscle is greater than that of the latter.

The deformities to which the head and neck are liable are:

1. ANTERIOR CURVATURE OF THE NECK (ROUND SHOULDERS, SO CALLED).
2. WRY NECK.
3. DISTORTIONS ARISING FROM BURNS AND OTHER INJURIES.

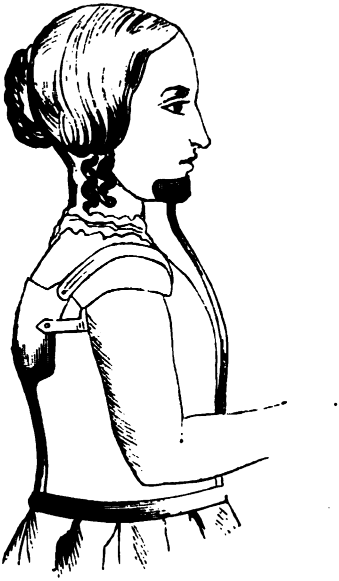
1. *Anterior curvature* is the commonest, and

also the simplest deformity of the neck. It is commonly known as *round shoulders.* The hitched up and arched shoulders which characterise this deformity are sufficiently indicated by the popular designation. Anterior curvature is chiefly met with among the young, and is frequently the result of an ill-habit. More frequently it is an indication of an enfeebled frame. From the great flexibility of the cervical portion of the spinal column, the ready yielding of the vertebral ligaments, and the aptitude of muscles to adapt themselves to definite modes of action impressed upon them, the neck is very liable to be fixed permanently in any exaggerated curve to which it may have been habitually subjected in childhood and adolescence. The habit of stooping contracted by indolent, lounging children, is a common source of anterior curvature. The over-studious are also subject to the same deformity from the constant bending forwards of the head and neck over the book or the desk. Weakly, overgrown children are most liable to suffer from round shoulders. The want of vigour in the whole system predisposes to the deformity. The muscles in these children appear to suffer, as it were, from permanent fatigue, and the ligaments are deficient in elasticity. The head is not carried well, and sinks between the shoulders. The neck, imperfectly "stayed" by its muscles and ligaments, is unable fully to support the superincumbent mass, and drops forward. The habits of school-life exaggerate these evils, and it often happens that a degree of deformity is induced which painfully embitters after-life.

Anterior curvature of the neck readily yields to mechanical treatment. The instrument best adapted to meet the slighter examples of this deformity is a leathern back-board, to be attached to the shoulders, and a chin-rest. The back-board consists of a padded plate, which is fixed against the shoulder-blades, the shoulders being held backwards by leathern caps attached to the plate. The head is supported in an erect position by a cup-shaped rest for the chin. The chin-rest and the back-plate are held in position by rods fixed to a leathern band which passes round the waist. The following woodcut (Fig. 12) shows the construction and mode of application of this instrument.

The back-plate and chin-rest have been, to a great extent, discarded by modern practitioners, and their place supplied by more complicated

FIG. 12.



pieces of mechanism. But in the slighter cases of anterior curvature no instrument gives more effective relief when properly applied, and none is so little costly.

When the anterior curvature occurs in an exaggerated form, or is complicated with contraction of the pectoral muscles, provision has to be made for the gradual restoration of the head and neck to their normal position. This is attained by various modifications of the back-board and chin-rest, according to the requirements of the case. Mechanism for extension is easily adapted to the instrument described, which forms the type from which the more elaborately constructed machines for the treatment of anterior curvature are mainly derived.

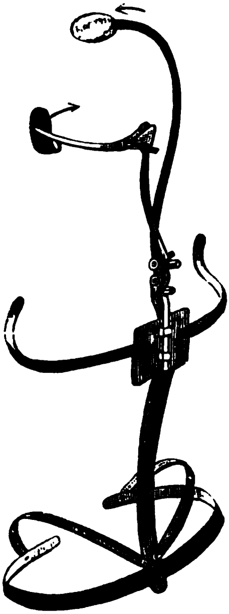
2. *Wry-neck* is caused by permanent contraction of one of the sterno-mastoid muscles. The head is rotated to a greater or less degree obliquely on its axis, the posterior part being drawn downwards and towards the shoulder on the side of the affected muscle, while the face is tilted upwards in the opposite direction. The term *wry-neck* has also been applied, but incorrectly, to the distortion of the neck which arises (1) from general lateral curvature of the spine; (2) from caries of the cervical vertebræ; (3) from the contraction of the cicatrix of a burn or ulcer; and (4) from glandular enlargement confined to one side of the neck.

In the mechanical treatment of genuine wry-neck the end sought is to replace the head in its normal position, and so retain it until extension of the morbidly contracted sterno-cleido-mastoideus muscle is induced. The means by which this end may be secured are also those best adapted to perfect the cure of a case when tenotomy has been had recourse to.

To control the head effectually, and at the same time act upon the cervical vertebræ, are among the greatest difficulties which the mechanician has to contend with. The head, from its configuration, is naturally disposed to rotate within any instrument constructed for its retention. The mechanician, moreover, is limited in his efforts to control the motions of the head by the necessity of so arranging his apparatus that it shall be obtruded as little as possible upon the sight. He is often trammelled in the greatest degree by the natural anxiety of patients for the concealment of the instrument beneath the dress.

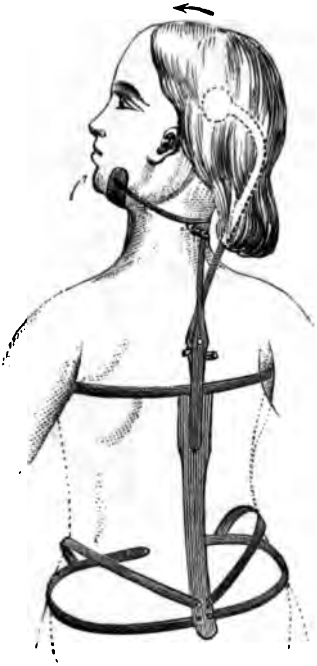
The mechanism which has been found most generally applicable and most effective in the treatment of wry-neck is constructed as follows (Fig. 13):—It consists of a padded pelvic band, to which is attached a vertebral stem with horizontal arm-pieces. At the upper extremity of the vertebral stem a neck-lever is fixed, to be attached or detached at will. This lever is formed in a peculiar fashion. It passes around the head

FIG. 13.



and rests by its outer extremity against the temporal bone on the side towards which the head is deflected. On the opposite side of the head a horizontal lever is fixed, also springing from the vertebral stem, and resting against the lower jaw. The temporal lever has a vertical axis, moved by a ratchet joint, upon turning which the head is gently pressed in a horizontal direction. The lower-jaw lever also acts horizontally, but in a different plane. (Fig. 14.) By the conjoined action of these two levers the contracted

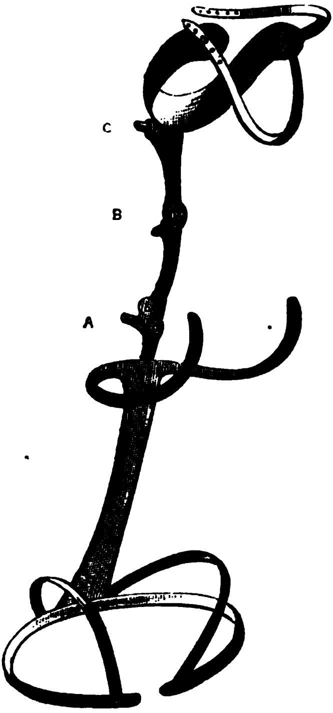
FIG. 14.



sterno-mastoideus muscle is extended, the head restored to an erect position, and the chin brought into the mesial line of the body. From the position of the lever, displacement of the head, when the instrument is properly applied, is impossible, and by a little modification of the dress and arrangement of the hair the mechanism may be almost entirely concealed.

An apparatus of different construction is in use at the Orthopædic Hospital. A vertebral

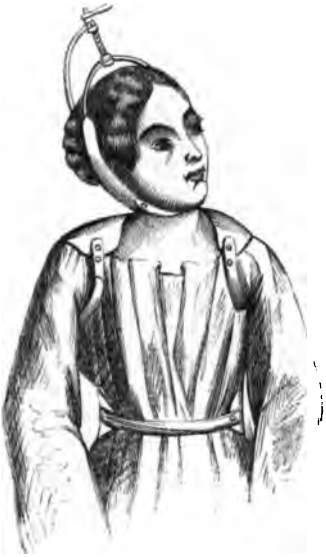
FIG. 15.



stem springs from a pelvic band. To the upper termination of the stem are affixed two arm-pieces and a head-lever. The arm-pieces pass beneath the axillæ. The head-lever supports a padded metal plate, and it has three centres of motion (Fig. 15, A, B, C). The metal plate is curved so as to grasp the occiput, and it is secured in position by forehead- and chin-straps. The lever can be moved from before backwards (A), or laterally (B), or rotated (C). This apparatus is open to the insuperable objection that the head is not firmly retained in position.

Bonnet has suggested an ingenious apparatus (Fig. 16) for wry-neck, which answers well in ordinary cases. It is not, however, to be trusted in cases where there is much contraction of the sterno-cleido-mastoid muscles, as the base of the head is not sufficiently under control. A gutta-percha shield is fitted to the back and shoulders, and is fixed in position by straps passing beneath the armpits and round the waist. To the upper margin of the shield is attached a metal rod. This rod is curved, and projects above the head, and it can be moved in a lateral and antero-posterior direction by means of a double-action ratchet centre. A simple screw at the extremity of the rod serves to connect with it two padded metal plates adapted to grasp the head on each

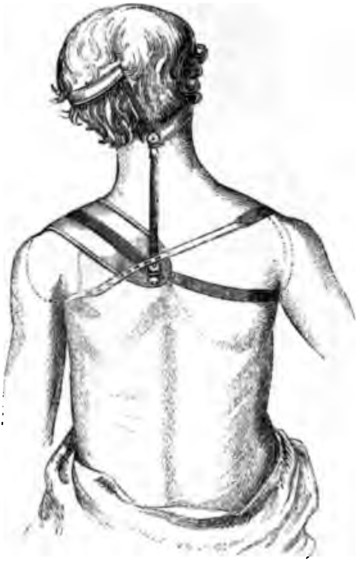
FIG. 16.



side. These plates, when fixed in position, are secured by a strap passing beneath the chin. When this instrument is applied the head may be moved in any direction.

The instruments hitherto described are attached to the trunk or the pelvis. In adults this is occasionally rendered impossible by a prominent abdomen. This difficulty may be overcome in the following manner (Fig. 17) :— A curved piece of steel rests upon the shoulder towards which the head is drawn, and is retained in its place by padded straps, which pass beneath the armpits.

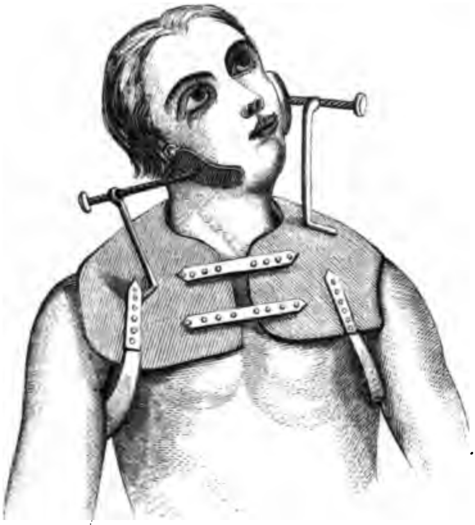
Fig. 17.



From the plate spring two levers with padded extremities. These levers are so arranged that one rests on the parietal region of the contracted side and the other on the mastoid process of the opposite side, their action being governed and directed by ratchet screws.

Bonnet also describes an instrument for wry-neck which is fixed to the shoulders (Fig. 18). A light metal collar is fitted to the shoulders

FIG. 18.



and fixed by straps passing beneath the armpits and across the breast. To this collar are attached two upright metal rods with horizontal screws. To these screws padded plates are attached, which press against the lower jaw on one side and the malar bone on the other. By the combined action of these screws the head may be brought gradually into an erect position.

Application of Instruments.—Assuming that the apparatus depicted in Fig. 13 is the one most likely to be adopted, it is to be adjusted in the following manner:

First. Detach the head-stem and its appendages from the thoracic portion, and carefully place the hip-bands around the pelvis, and let the axillæ rest in a natural attitude upon the arm-pieces.

Secondly. Attach the head-stem, loosen the ratchet screws governing the vertical and horizontal axes, and then screw the head-stem at such a height as to bring the horizontal lever on a level with the mastoid process on the side of declension.

Thirdly. Screw the levers until the vertical one rests gently upon the parietal region and the horizontal on the inferior maxilla, and fix the head-straps.

Fourthly. Tighten gradually every other day the vertical lever, moving the horizontal one only every fourth day, until the head is restored to an erect position.

By making the vertical lever the medium for the application of force in a lateral direction, whilst the horizontal stem is maintained as a kind of "point d'appui," extension of the contracted tendon in its true plane of movement is more perfectly secured than if both ratchet axes were acted upon simultaneously. After the head is once restored to its normal position the instrument should be left alone.

Should the apparatus prove at this time irksome, a collar of thin gutta percha, carefully moulded to the upper part of the chest and lower portion of the jaw, will serve to keep the head in position until equilibrium is established by natural means.

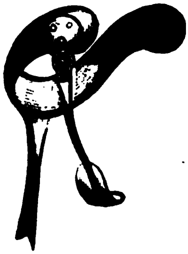
3. *Distortions from Burns and other Injuries.*

A. *Distortion from Burns.*

The cicatrices of burns frequently give rise to the most distressing deformity of the head and neck. It is possible by mechanical means so to fix the injured parts as to prevent to a greater or less extent the contraction to which the cicatrix is liable. The question of the prevention of deformities arising from cicatrices, by mechanical agency, has not as yet received that attention from surgeons which it deserves. Hitherto the orthopractic mechanician has been chiefly required to remedy rather than prevent the evils arising from this source. The instruments about to be described, which have been devised for the extension of cicatrices, are also adapted to fix the head and chin while the process of healing is going on, so as to prevent or limit contraction.

Ordinarily the chin is drawn downwards, the head being more or less deflected to one side. Occasionally the lips are also everted. When the displacement of the chin is the main distortion, the head being but slightly deflected, the instrument depicted in Fig. 19 may be adopted.

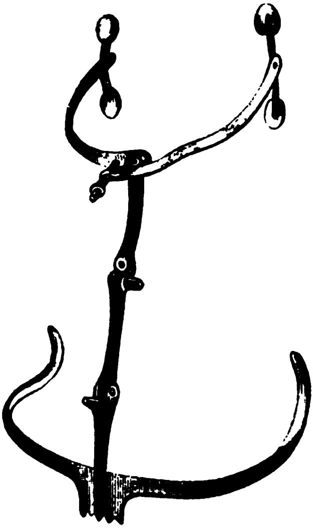
Fig. 19.



A curved padded plate grasps the occiput, the extremities extending as far forwards as the temporal region. From the right or left arm of the plate, according to the requirements of the case, depends a chin-rest. The curved plate is attached to a head-stem, which may be moved horizontally or vertically, and which in turn is affixed to a vertebral stem, the latter being furnished with a pelvic band and arm-rests. By means of this apparatus the head may be brought into a vertical position and retained there, and the chin elevated.

Another form of instrument, adapted to severer cases of distortion, is depicted in Fig. 20. The arrangement of the vertebræ- and head-stems is

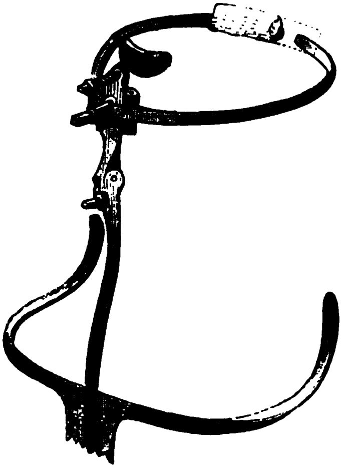
FIG. 20.



the same as in the instrument previously described. From the extremity of the head-stem spring two curved levers, which are attached to the stem by a joint moving on a vertical axis. By means of a screw the distance between the outer extremities of the levers can be increased or diminished. The levers carry two vertical rods, so arranged that the ends, properly padded, rest against the temporal and superior maxillary bones. By this mechanism the head can be more completely controlled, and more power can be exercised over it, than by the instrument first described.

A third form of instrument has been devised to prevent or remedy eversion of the lip (Fig. 21). It is adapted also for the elevation of the chin. Two semicircular arms spring from a cervical stem. The anterior extremities of the arms carry a movable pad, formed to rest against the chin. An occipital plate, moved by a screw, regulates the pressure which may be exercised by the pad against the lip; and the cervical stem has a vertical axis by means of which the chin may be uplifted. A vertebral lever, pelvic band, and horizontal arm-pieces, complete the instrument.

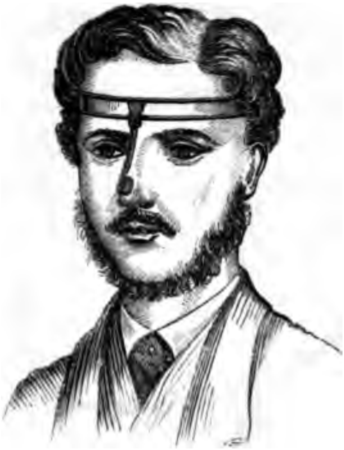
Fig. 21.



B. *Distortions of the Nose.*

Occasionally the nose may be distorted by injury. A barrister was thrown from his horse. His face struck the sharp stump of a tree, and the violence of the blow deflected the nose considerably. The distortion remained after the pain and swelling of the bruised parts had passed off, and unfortunately gave so eccentric an aspect to the face as to prevent the gentleman appearing

Fig. 22.

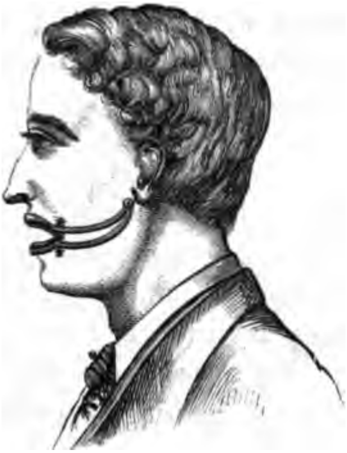


in public. To remedy this evil a well-padded circular metal spring (Fig. 22) was adapted to the head in a line above the eyebrows. To the centre of the spring was attached, by a ratchet axis, a vertical lever. This lever rested upon the side of the nose towards which the deflection had taken place, and the degree of pressure exercised by it could be regulated at will by the axis. By means of this mechanism the deformity was gradually reduced, and in the end entirely removed.

c. *Distortion of the Mouth.*

The adaptability of mechanism to the relief of distortion of the mouth is limited to extension of the jaws when closed by spastic contraction of the masseter and temporal muscles. This troublesome affection is, when mechanical aid is not contra-indicated, best dealt with by an apparatus constructed in the following manner (Fig. 23).

Fig. 23.



Two firm but thin rods of metal are accurately modelled to the chin and articulated at the point where the lower jaw has its axis of movement. To each rod is fixed a horizontal metal lip, which, having been first covered with india rubber, is inserted between the lips. By means of two vertical screws, fixed at the angles of the lips, the rods can be separated from each other and the mouth gradually opened. This instrument, from its form and arrangement, retains its position without the assistance of straps or bandages. It is an admirable gag for keeping the mouth open during surgical operations on the tongue, the use of the stomach-pump, the injection of nourishment in lunacy when all food is persistently refused (sitophobia), and the forcible administration of nauseous medicines.

Distortions of the eyes and appendages, so far as they admit of being remedied by mechanical appliances, although coming strictly within the limits of orthopraxy, form part of a special branch of surgical science, and need not be discussed here. The same remark applies also to *distortion of the face* arising from defects of the teeth.

SECT. II.—DEBILITIES.

Muscular debility is a common cause of deformity. In life and health the muscles are never entirely passive. When uninfluenced by the will—when what is popularly termed *at rest*—they remain in a state of static contraction. To this action, which has been inaptly designated tonicity or passive retractility, the maintenance of the symmetry of the frame is mainly due. The different groups of muscles antagonise or harmonise with each other, and give rise to that exquisite state of equilibrium of the entire muscular system and the skeleton which constitutes the great beauty of man. Any deviation from this state of equilibrium occasions deformity. This may arise from morbid contraction of certain muscles or groups of muscles. In *wry-neck,* the mechanical treatment of which has already been discussed, the sterno-cleido-mastoideus is in a state of spastic contraction. A like condition of the various muscles of the leg gives rise to different forms of club-foot. Or a deviation may be caused by atrophy of one or more muscles or groups of muscles, and consequent undue action of the opponents, from the withdrawal of antagonising force. The atrophy may be a result of long-continued inaction, whether arising from paralysis or not, or of a peculiar degeneration of the muscular tissue (*wasting palsy*), or of changes occasioned by rheumatic or subacute inflammation. Or, again, a deviation may be caused by paralysis of certain muscles or groups of muscles dependent upon disease or injury of the nervous centres, or of the nerves distributed to the affected muscles; or the paralysis may arise from exaggerated emotion, as in hysteria.

As the common characteristic of atrophy and paralysis is an enfeeblement of muscular action, the different forms of these lesions may, for the purposes of this treatise, be conveniently classed together as debilities.

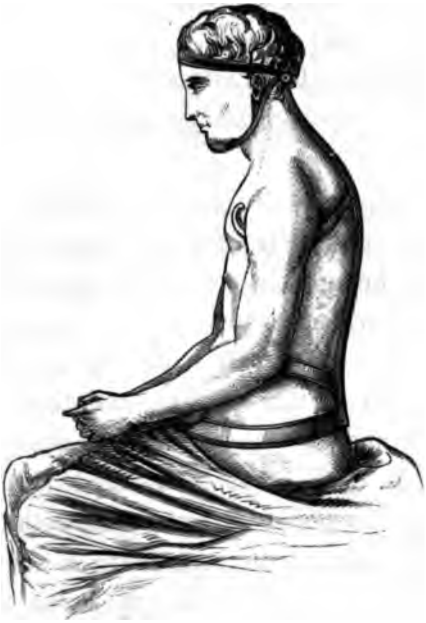
In the same category may also be included deformities of the neck arising from disease of the cervical vertebræ, such disease being invariably the result of a debilitated condition of the frame.

The debilities of the head and neck which admit of mechanical treatment are as follows:

1. PARALYSIS OF THE CERVICAL MUSCLES.
    (A.) *Posterior.*
    (B.) *Lateral.*
2. ANGULAR CURVATURE.
    — *Cervical gymnastics.*

1. *Paralysis of the posterior cervical muscles*, and more especially of the trapezius, prevents the head being held erect. The chin falls forward, and when the paralysis is complete, rests heavily upon the breast. By mechanical aid an amelioration of this painful condition may be obtained, and the use of other remedies much facilitated. Where systematic medical treatment has altogether failed to restore the action of the paralysed muscles, mechanical aid is alone available. If the head has simply fallen forwards from defect or absence of counteracting force, it may be at once placed in its normal position and retained there. If, however, the anterior cervical muscles should have become contracted, the process of replacement must be carried out gradually. One form of instrument is best adapted to meet the requirements of both cases. This instrument (Fig. 24) consists of a pelvic band, vertebral stem, and axillary supports

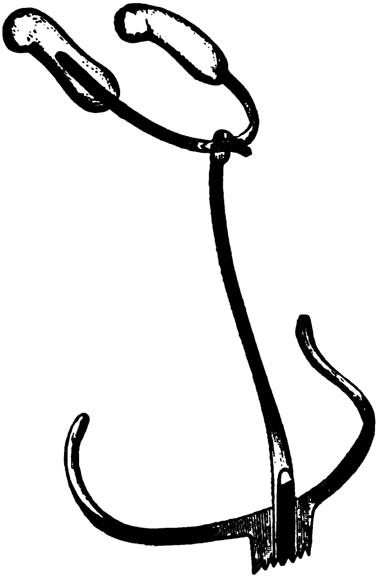
Fig. 24.



To the upper extremity of the stem two horizontal, curved levers are attached, and so arranged, that their padded extremities may be approximated or separated by means of a ratchet screw. A vertical axis, acted upon by a key, permits the levers to be elevated or depressed. When in position, the padded extremities of the levers rest beneath the chin. A strap passing across the forehead assists in keeping the apparatus in its place.

A modification of this apparatus, adapted also for the relief of angular cervical curvature, is depicted in Fig. 25. The levers in this arrangement, as in the former one, admit of being elevated and depressed, and of the intervals between them being increased or diminished, but they are curved so as to grasp the head from the

FIG. 25.

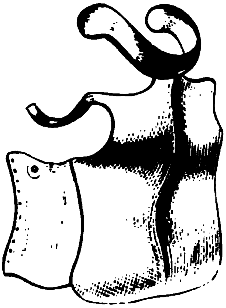


occiput to the temporal region, and are terminated by oblong, padded plates. Thus constructed, they may be concealed beneath the hair. This apparatus fixes the neck in an immovable position, and in disease of the cervical vertebræ gives the same advantages as recumbency, while enabling the patient to move about without exaggerating the mischief in the spine.

The deformity arising from paralysis of the *lateral cervical muscles*, in which the head falls, or is drawn somewhat forwards and towards the unaffected side, may be relieved by an apparatus differing only from those described in the preceding paragraph by the arrangement of the levers and the addition of a lateral axis, governed by a key, and fixed at the junction of the cervical and dorsal portions of the vertebral stem. The head having to be raised from the shoulder and prevented falling laterally, the levers are constructed with broad, pyriform extremities, and so placed that they may rest upon the temples, grasping them hand-like.

Another piece of mechanism for holding the head and neck at rest, may be formed by fitting accurately to the back and nape of the neck a piece of gutta percha, to which is affixed, at the

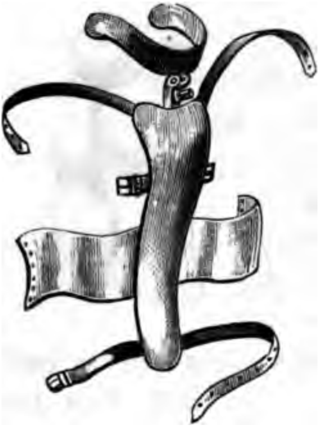
FIG. 26.



upper margin, a slight metallic band, shaped to the occiput. (Fig. 26.) This instrument is peculiarly well fitted for young children. The head rests in the bands without pain or trouble, and the patient can be turned or moved easily without fear of mischief being done to the diseased vertebræ.

Mr. Bishop has suggested a very valuable apparatus for angular cervical curvature. It is composed of a light padded plate, accurately moulded to the spine, and having at its upper margin an occipital rest, which possesses free motion horizontally and anteriorly, partial motion posteriorly, but no motion at all laterally. When this apparatus is applied and firmly secured by shoulder loops, thoracic and pelvic bands

FIG. 27.

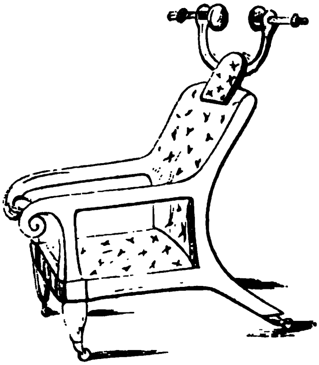


(Fig. 27), it supports and fixes the cervical portion of the spine, while permitting free motion of the head in every direction but that likely to do harm.

It is indispensable that every apparatus intended to control the head should be attached to the pelvis, otherwise it would be liable to displacement by every movement of the shoulders and chest.

A plan frequently adopted for the relief of disease of the cervical vertebræ in Germany is to place the patient in a semi-reclining posture on an invalid chair, to which a neck-piece is

FIG. 28.



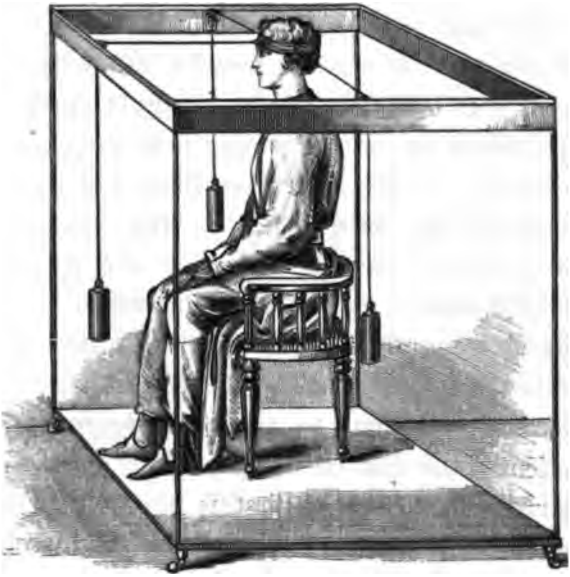
fastened (Fig. 28) and so arranged as to hold the head immovable, somewhat after the manner in which the latter is occasionally fixed for photography. Or, instead of the neck-piece, two bags of sand are used, between which the head is placed.

Application of Instruments.—In applying any one of the instruments described in this section, first secure it firmly to the trunk, and then gently act upon the head. The mechanism should always be adjusted to the patient from behind, by which means the surgeon sees that the pelvic portion is firmly secured, without which the head cannot be correctly controlled.

Gymnastics of the Neck.

Systematic exercise of the muscles of the neck is one of the most important modes of remedying or relieving the deformities arising from spasm, paralysis, or ill-habit. This exercise is often best effected, and in many instances can alone be carried out, by mechanical agency. A simple and very excellent cervical gymnasium may be constructed in the following manner (Fig. 29): or the portable gymnasium to be afterwards described (Chap. III.) may be arranged so as to serve also as a cervical gymnasium. A stout frame, four feet square, is fixed firmly upon legs, one at each corner, of about four feet six inches in height. To the centre of each side of the frame a pulley is attached. Within the framework thus constructed is placed a chair, the seat of which can be elevated and depressed after the fashion of a music-stool. The apparatus is completed by a padded strap to buckle round the head, cords with hooked extremities which pass over the pulleys, and weights of various sizes to be attached to the cords. The object of this arrangement is to antagonise the excessive action of

Fig. 29.



muscles affected with spasm, or of which the counteracting force has been removed or diminished by paralysis, or the enfeeblement arising from inaction of the opposing muscles. An enfeeblement from inaction of certain muscles or groups of muscles is the source of the deformities —*mauvais posès*—which are sometimes observed in indolent or weakly children as the result of lounging habits. The patient being placed on the chair, the strap is buckled round the head, and the weights are so arranged as accurately to counterbalance the overacting muscles. If these be the anterior cervical muscles, the weight is brought to bear on the posterior part of the head, by hooking one of the ropes to the strap in this position. If the lateral cervical muscles are dragging the head laterally, the weight is fixed to the inactive side; if the posterior cervical muscles are affected, the weight is attached anteriorly. When the distorting force is thus counteracted, the patient is instructed to place or endeavour to place perseveringly, and patiently, the inactive or paralysed muscles in action. The effort at first is often wearisome and repulsive, and when, in paralysed muscles, little voluntary motion remains, it is frequently most disheartening. But the amelioration which may from time to time be secured even in the most obstinate cases by persistent efforts is almost incredible, and the patient should always be encouraged to the utmost.

SECTION III.—DEFICIENCIES.

Defects of structure, whether arising congenitally from arrested development, or from injury, disease, or surgical operations, as from excision and amputation, are a common cause of deformity. The head and neck is less liable to disfigurement from this source than the limbs. The deficiencies in this region of the body, to relieve which the aid of the mechanical therapeutist is required, are as follows:—

1. DEFICIENCY OF NOSE.
2. DEFICIENCY OF LIPS.
3. DEFICIENCY OF EARS.
4. DEFICIENCY OF PALATE.
5. DEFICIENCY OF CHEEK.
6. DEFICIENCY OF EYE.

So successful have been the efforts of surgery, by transplantation of living tissue, in restoring the nose when destroyed by disease or accident, and in relieving the disfigurement and discomfort arising from malformed palate and hair-lip, that the need of mechanical aid in the treatment of these deformities has been greatly diminished. Nevertheless, there are still cases in which the skill of the mechanician must supplement the work of the surgeon. The necessity occasionally, arises for the fabrication of an artificial nose, or lip, or palate, in order adequately to remedy the evils arising from the ravages of disease.

1. *Deficiency of Nose.*—The fabrication of an artificial nose holds much the same position in mechanical therapeutics that the construction of a new nose does in conservative surgery. The moulding of an artificial organ, as the formation of a new one from living tissues, demands the highest delicacy of manipulation.. The artificial nose is best fabricated of silver. A thin sheet of this metal is fashioned so as to represent as accurately as possible, in size and shape, the missing organ. The almost universal existence of photographic portraits of individuals greatly facilitates the mechanician's endeavours to frame a resemblance to the original member. After the artificial organ has been accurately moulded, not only in form, but also in its adaptation to the face, it is fixed in its place by a pair of spectacles, to the

bridge of which it is attached. When thus fixed it is carefully painted the colour of the adjacent skin by a skilful artist. The difficulty of detecting a nose thus constructed, except on close investigation, is astonishing.

Aluminium, gutta percha, and india rubber are also used in the manufacture of artificial noses. Aluminium has been substituted for silver on account of its great lightness and extreme tenacity, but it does not admit of such accurate manipulation as the latter metal. The advantages of using gutta percha or india rubber are these—the artificial organ made from either substance is soft to the touch, and it can be attached directly to the face. The disadvantages of an artificial nose of gutta percha or india rubber are, that it is heavier and more oppressive to the face than one made of silver or aluminium.

The fabrication of an artificial nose from gutta percha or india-rubber is conducted in the following manner: A plaster of Paris cast of the disfigured face is first taken. Upon this cast a nose is carefully modelled in clay. From the cast thus completed a metal matrix or hollow mould is obtained, and so arranged that on fluid india rubber or gutta percha being poured in, a cast of the modelled nose is yielded. The cast, after it has cooled, is next removed from the mould, and, if formed of india rubber, it is vulcanized; then it is accurately fitted to the face and coloured so as to represent the natural organ; finally it is attached to the face by a thin film of collodion. With moderate care an artificial nose thus constructed may be readily fixed in its place and detached.

2. *Deficiency of Lips.*—The lips are occasionally the seat of destructive disease, and it sometimes becomes necessary, in order to prevent a distressing trickling of saliva, to construct an artificial substitute for the lower lip. The best substitute is a shield of silver, fitted to the chin, and moulded at the upper margin in the form of a lip. To the lower margin of the shield is attached an india-rubber bag for the reception of saliva. The shield and artificial lip are carefully painted to represent the natural parts, and the caoutchouc receptacle can be hid beneath a cravat.

3. *Deficiency of Ears.*—The ear is also liable to destructive disease. Artificial ears are moulded of silver, painted so as to represent the natural organ, and fixed in their place by a spring passing over the vertex of head.

4. *Deficiency of Palate.*—Cleft-palate is a congenital affection. It is apt to give rise to much annoyance and discomfort, particularly regurgitation of food and drink into the nostrils, and thickness of articulation. If the lesion does not admit of being remedied by surgical operation, or the knife is objected to, relief may be obtained by the use of an artificial palate.

Artificial palates are constructed either of gold or vulcanite. If gold be the material used, a mould is first taken in wax of the cleft palate, in the same manner as a dentist takes a mould of the teeth. A plate of gold is then carefully fitted to the cleft, as shown in the model. To the upper portion of the plate is soldered a tongue of the same metal, and to this tongue is attached a piece of sponge, somewhat larger in size than the cleft which the plate is intended to fill. When the plate thus arranged is fixed in position, the sponge absorbing the moisture from the neighbouring parts, swells, and sustains it firmly in site. If the apposition of the edges of the artificial palate to the cleft be accurate and the sponge be rightly fixed, there need be no fear of accidental displacement of the apparatus on inspiring through the nostrils; and, the cleft being closed, regurgitation of food and drink into the nostrils and thickness of articulation at once cease.

If vulcanite—india rubber rendered corneous by intense heat—be used for the fabrication of an artificial palate, the material, when in a softened state, is directly moulded to the cleft. The advantage of vulcanite is the great accuracy with which it can be adapted to the edges of the fissure. The advantage of gold is its freedom from corrosion.

Loss of an *eye* is one of the most grievous sources of deformity. Although Paré pointed out, in the sixteenth century, in what manner this defect might be remedied, it was not until a comparatively recent period in the present century that a thoroughly satisfactory artificial eye was produced. Now, however, so exquisite an imitation is made of the missing organ, whatever its hue, that it is impossible to distinguish the real from the artificial eye, when the latter is fixed in its place, without a close inspection.

If the ball of the eye be retained, and preserve its mobility, the difficulty of detection becomes still greater. The artificial eye is made of glass, "counterfeited and enamelled," as Paré writes, "so that it may seem to have the brightness and gemmy decency of the natural eie."

The relief of deformity arising from deficiencies of the *teeth* has become the duty of a separate profession, and needs no comments here.

CHAPTER II.

THE UPPER EXTREMITIES.

I.—DEFORMITIES.

DEFORMITIES of the upper extremities, although less obtrusive to the eye than those of the lower, are not less important as drawbacks upon the usefulness or comfort of the individual. They chiefly arise from mischief in the joints (from whatever cause arising), contraction, and in old standing cases even shortening of the flexor muscles, and the cicatrices of burns.

(1). CONTRACTION OF THE SHOULDER.
(2). CONTRACTION OF THE ELBOW.
(3). DISTORTION OF THE FORE-ARM.
(4). DEFORMITIES OF THE WRIST AND FINGERS.
(5). CONTRACTION FROM THE CICATRICES OF BURNS.

1. *Contraction of the Shoulder-joint* is a very rare affection. I have had to deal with it mainly as a result of gun-shot wounds, which have ren-

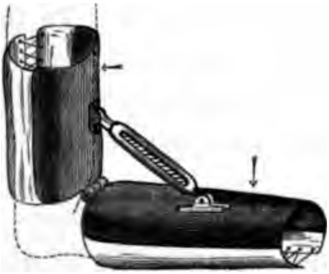
dered necessary amputation of the arm. In these cases the patients have been unable to extend the stump, in consequence of contraction of the muscles surrounding the joint. Prior to the adjustment of an artificial arm it is necessary to secure free motion of the stump. In order to effect this, when the joint has become fixed from contraction of the muscles, it is best to mould accurately to the clavicle, and upper part of the scapula a gutta-percha shield. To this shield a lateral lever furnished with a ratchet joint is to be attached, and so arranged that when the screw is acted upon extension of the stump is obtained.

2. *Contraction of the Elbow.*—The most ordinary form of contraction of the elbow is simple flexion of a permanent character, arising from retraction of the flexor muscles. This may have been brought about by the arm having remained bent for a long time in one position, during long and wasting illness, or in consequence of some painful affection of the joint, or as a result of injury to the arm. If the tension of the rigid muscles be great, tenotomy may be required in conjunction with mechanical treatment. In the majority of cases, however, a

well-constructed instrument will suffice to unbend the arm and restore the flexibility of the elbow.

The instrument commonly made use of in these cases is a double splint, connected at one extremity by a hinge, and fixed in an angular position, by an elongating screw (Fig. 30). This splint is arranged so that it can be placed upon the inner surface of the flexed extremity, and when thus adapted extension is effected by means of the screw. It would be difficult to conceive a more unsatisfactory and less scientific form of apparatus for the special object sought to be attained. The mechanical centre of the splint does not coincide with the axis of the elbow-joint as it ought to do, but is placed nearly an inch above it. Further, the position and arrange-

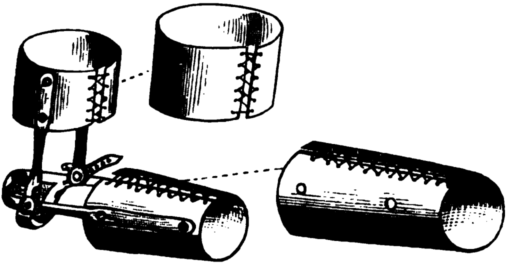
Fig. 30.



ment of the screw do not admit of full extension of the arm.

The proper form of apparatus to be employed in the cases under consideration, consists of two lateral levers, jointed at the elbow, and with a padded metal trough for the fore- and another for the upper arm. The outer joint is governed by a rack and pinion movement, which permits the gradual extension of the articulation without pain or inconvenience (see Fig. 31). A soft leather cap receives the elbow, and constitutes a point of counter-resistance when extension commences.

Fig. 31.



At the suggestion of Professor Longmore, I have fitted this apparatus with a set of upper and lower arm troughs of various sizes (see Fig. 31), so that the same levers may be adapted to different cases. I have also arranged extending apparatus for the knee in a similar manner. The utility of both forms of mechanism for army surgeons and hospitals is thus increased.

When the elbow joint is rotated as well flexed, as when the wrist is turned inwards and outwards, a modification of the apparatus described is needed. The internal lateral lever is done away with, the external one only being retained, and to this a second ratchet-centre is attached, so formed as to agree with the plane of rotation. This deformity is, however, very rare, as is also lateral inversion of the elbow. When this latter condition exists, a well-padded splint bound tightly to the arm, is the mechanical appliance to be adopted.

A common form of contraction of the elbow is that which arises from semi-anchylosis of the joint. In these cases the patient cannot either extend or flex the joint, but on the application of considerable force, some degree of motion is found, constituting the distinction between true anchylosis or bony union of parts and false anchylosis or cartilaginous adhesion. In these cases the flexor muscles of the arm are thrown into a state of spastic contraction, and if the mischief in the joint is of old standing, they not unfrequently become shortened. In treating a case of semi-anchylosis the object first sought is to break down the morbid adhesions in the joint. This may be effected by one operation, or by a series of operations. If the former, the patient is placed fully under the influence of chloroform, not merely to allay pain, but also to relax the contracted muscles, and to prevent those violent contractions which else the pain would induce; then the limb is forced into a straight position and the morbid adhesions about the joint broken down. To prevent renewed contraction of the joint and secure motion, a special splint is required, which will presently be described (p. 133).

If the degree of force required to break down the adhesions immediately prove to be such as the surgeon hesitates to use, or if it be considered advisable to proceed from the commencement by a series of operations, recourse must be had to mechanical means. Blanc of Lyons has constructed an apparatus for this purpose (Fig. 32), a graduated scale with index being attached, by means of which the force used may be measured.

3. *Distortion of the Fore-arm.*—I once had occasion to devise a rather complicated piece of

mechanism for a case where the greater portion of the radius had been excised. Owing to the carpal bones losing their ordinary support, the hand dropped in a lateral direction, and the whole fore-arm became shortened. It was sought to restore the hand to its natural position, and cause an extension of the fore-arm. To accomplish these objects was a work of no ordinary difficulty, but in the end I succeeded. The instrument made use of is depicted in Fig. 32, the following drawing. It was formed by a grooved metal splint, which was well-padded, and which rested upon the ulnar surface. This splint was fixed in its place by a strap below the elbow, and by a broad laced bandage passing over the radial sur-

Fig. 32.

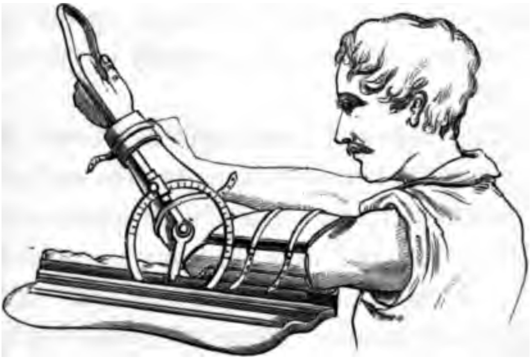
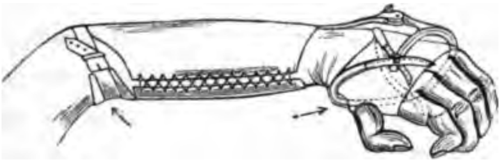


FIG. 33.

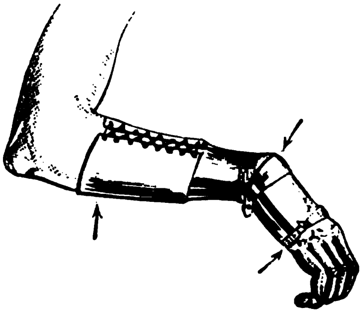


face. Opposite the wrist a ratchet-joint was fixed, to which was attached a double lever, so arranged as to hold the palm and back of the hand between its limbs. The hand was fastened to the lever by means of a leathern gauntlet, attached by metal studs. By acting upon the ratchet-joint the wrist and hand were raised and the fore-arm extended. The grasping power of the fingers remained unimpaired after the operation, and by means of the instrument described the patient has secured a very useful hand and arm.

4. *Deformities of the Wrist and Fingers.*—Deformities of the wrist-joint consist in simple, permanent flexion, extension, transverse rotation, or lateral deviation. Occasionally two or more of these conditions are combined.

Those distortions of the wrist, which are distinguished by flexion of the joint, generally present a tense condition of the tendons which traverse its inferior surface; the dorsal or upper part of the joint becoming extremely rounded and prominent. To elongate the muscles and restore the joint to its natural position, it is customary to employ first tenotomy, and subsequently, by the use of a well-adjusted instrument, effect gradual extension. An appliance invented for the latter purpose is as follows:—Two lateral stems are affixed to a metal trough, and, at the point where they coincide with the wrist-joint, a ratchet-centre is formed. Resting against the palmar surface of the hand, and across the metacarpal extremities, is a softly padded plate connected with the lateral levers.

FIG. 34.



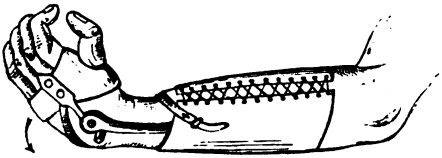
When applied, the trough of the instrument receives the under surface of the fore-arm whilst the hand-plate rests against the base of the fingers; the lateral levers being flexed by means of their ratchet-joint, so that the angle formed by the apparatus is equal to that of the contracted wrist-joint. A strong but well padded leathern band passes over the upper and prominent part of the wrist. On extending the artificial joint, resistance of the limb against the instrument occurs at the trough, the hand-plate, and the wrist-band. These three surfaces form the apex and base of a triangle; and as the tendinous region is involved in the base, it undergoes an elongation proportionate to the separation of the extremities of the lateral levers.

Other instruments exist for the treatment of this deformity, but they are rarely used. The only one requiring to be mentioned in addition to that already described, is a padded splint, hinged with a ratchet-joint just above the dorsum of the wrist, upon the extension of which the anterior portion of the wrist-joint is uplifted, and the contracted muscles extended. An almost insuperable objection, however, to this arrangement is, that so great an amount of pressure is brought to bear upon the back of the wrist by reaction, that a continuous employment of the mechanism becomes impossible; and interrupted treatment rarely leads to good result.

Another form of wrist deformity is that resulting from contraction of those muscles which extend it. The hand is, in consequence, maintained in a straight and rigid position. The inconvenience of this condition may be comprehended, when it is recollected how many of those natural actions which we are called upon to perform daily, demand the power of freely flexing the wrist-joint. In fact, although contraction of the extensors in such a degree as to hold the wrist in a straight position is barely a distortion, yet it is far more inconvenient than any other form of wrist affection. The mechanical apparatus by means of which this deformity is overcome greatly resembles that adopted for acting against contracted flexors, the only difference being, that in the latter the hand-plate passes under the palm, whilst in cases of contracted extensors the force is required to be exercised in a downward direction against the back of the hand, thus reversing the plan adopted for extending a contracted wrist-joint of ordinary appearance and character.

A third kind of wrist deformity occurs when those muscles (or their tendons) which belong to the inner lateral margin, or, rather, radial region of the arm, become shortened. In this case the most valuable apparatus for overcoming the deformity, is one in which the forearm is received in a kind of trough, while at the centre of the wrist, and on its upper surface, a ratchet-centre is placed, corresponding as far as possible with the axis formed by the bones of the wrist in their displaced condition. The hand itself is also enveloped by a padded

FIG. 35.



plate, surrounding both its palmar and dorsal surfaces, and connected with the centre-ratchet just mentioned. On bringing this instrument into operation, extension of the inner margin of the wrist is obtained.

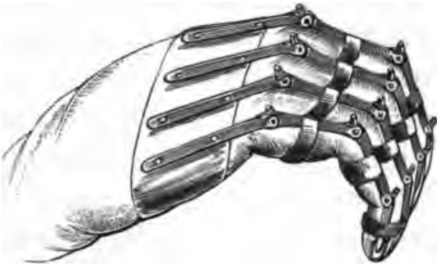
Rotation of the wrist upon its own axis, although a rare form of distortion, sometimes occurs. To remedy this deformity, the same instrument as that just described is employed, with this difference, that the ratchet is fixed so as to act in a plane transverse to that of the dorsal surface of the hand, and thus gradually rotate and replace the distorted parts.

Contraction of the fingers from injury is of all deformities perhaps the most troublesome. Whatever interferes with the flexibility of the fingers, diminishes the utility of the hand in a degree altogether disproportionate to the seeming magnitude of the deformity. A single finger may be contracted, or the whole of the fingers of one hand. In the latter case, the hand is useless; but occasionally, even in apparently the most hopeless instances, benefit may be derived from mechanical appliances, as the following example will show.

An officer in the Indian service received a wound across the palm of the hand from a tulwar, during the Sikh campaign. Considerable sloughing occurred, and, on cicatrization taking place, the contraction of the fingers became so great that the handle of a sword could not be grasped. I endeavoured to relieve the excessive contraction by the instrument shown in the following woodcut (Fig. 36).

It will be seen that a padded plate rests upon the dorsal surface of the hand, to which are attached five jointed rods, four of which follow

FIG. 36.



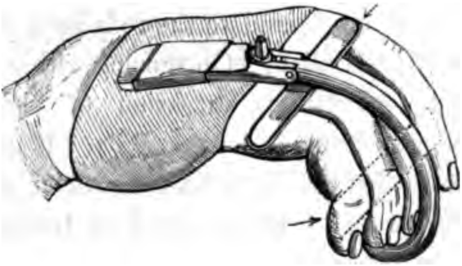
the course of the fingers, and the other of the thumb. Corresponding exactly with each articulation is a ratchet-joint governed by a key. The fingers are bound to the rods by a piece of narrow black ribbon. On moving either of the artificial articulations extension of the joint over which it is placed results. It will be perceived that no less than fourteen distinct axes of extension are required in treating the thumb and fingers.

By this piece of mechanism a very useful hand was obtained. The patient was again enabled to hold his sword and perform almost any act dependent upon the free use of the fingers.

Another very valuable invention for contraction of the fingers is constructed as follows:

A padded leathern band surrounds the wrist. To the upper surface of the band a socket is attached; and in this socket a curved lever, having two horizontal bars, is fixed. One of these bars passes under the palmar surface of the first joint of the fingers, the other passes over the dorsal surface of the third joint of the fingers. A small ratchet-centre also exists in the curved lever, which, upon being moved gently, extends the whole of the fingers, by pressing upon them at the back while uplifting their extremities. This appliance is calculated to overcome the most severe case of finger deformity.

Fig. 37.



When the forefinger is contracted, as frequently occurs, a little plate fixed at the back of the hand, and furnished with a lever acting in the same manner as in the intruments above described, soon restores the part to its natural form.

(5.) *Contractions from burns.*—Occasionally the cicatrices of burns lead to various contractions, and much distortion of the upper extremities; but as the mechanical means required for the extension of a cicatrix are the same as those required for the extension of contracted muscles, it is not necessary to enter into detail.

In concluding this section, it is important to mention the instrument which is needed to prevent a recurrence of distortion after the extension of contracted joints has been effected. This consists for the elbow and wrist-joint of a very light metallic frame, jointed at the point of flexion, and furnished with what is known as a stop-joint. By this appliance extension can be kept up at intervals until the muscles have recovered their proper equilibrium.

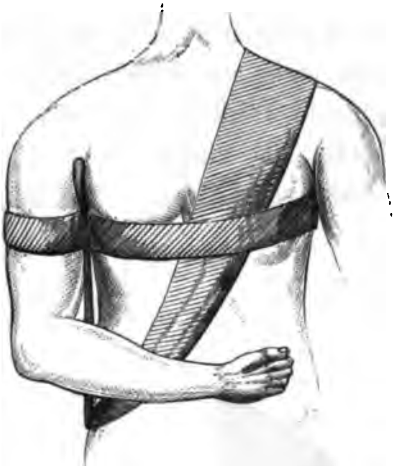
II.—DEBILITIES.

The chief forms of debility of the upper extremity, which admit of being ameliorated by mechanical aid, are as follows:

1. DROP-SHOULDER.
2. PALSY OF THE FOREARM.
3. DROP-WRIST.
4. CONTRACTED FINGERS.
5. (*a*) WRITERS' OR SCRIVENERS' CRAMP.
   (*b*) COMPOSITORS' CRAMP.
   (*c*) MUSICIANS' CRAMP.
   (*d*) SHOEMAKERS' CRAMP.
   (*e*) SEMPSTRESSES' CRAMP.

1. *Drop-shoulder.*—This condition arises either from laxity of the ligaments which maintain the head of the humerus in apposition with the glenoid cavity, or from paralysis of the deltoid and scapular muscles. When the ligaments have lost their elasticity and become extended, the head of the humerus falls out of the glenoid cavity—there is permanent dislocation of the shoulder. In these cases the best mechanical treatment is to place a short crutch beneath the axilla (Fig. 38)

FIG. 38.

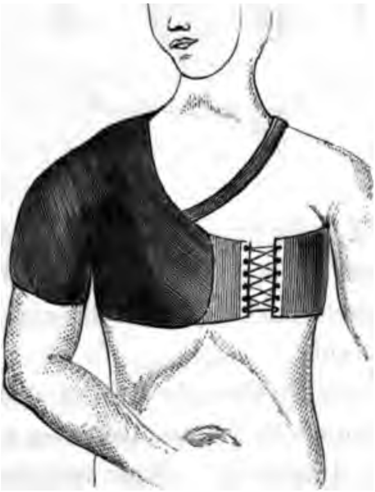


retaining it in its place by a broad-webbing band passing over the opposite shoulder, and by a belt which encircles the chest and fixes the affected arm to the side.

This is almost the only form of dislocation of the humerus which requires persistent and special mechanical treatment. Other varieties admit of reduction, and the bone is readily kept in place by the ordinary Brasden bandage, which consists of two padded shoulder-caps, which are buckled together behind between the scapulæ.

When the displacement of the shoulder-joint arises from paralysis of the deltoid and scapular muscles, the head of the humerus may be retained in its normal position by means of a gutta-percha shield which embraces the affected shoulder and upper arm, and which is also fitted to the side of the thorax. The shield is kept in position by a shoulder-strap and corset. (Fig. 39.)

Fig. 39.

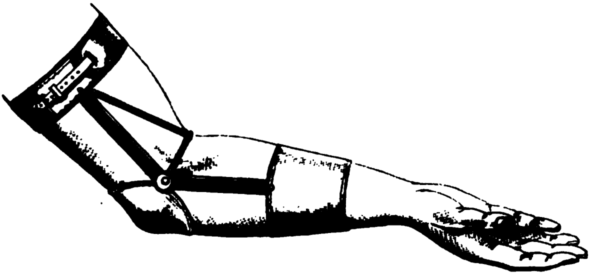


2. *Palsy of the Forearm.*—Inability to bend the forearm from paralysis of the flexor muscles may be satisfactorily dealt with in the following manner. The object sought is to supplement artificially the action of the debilitated muscles.

The arm and forearm are inclosed in two well-fitting troughs which are connected by an external and internal steel-band, attached to a cap for, and jointed at, the elbow. From the lower arm of each steel-band, at the point of flexion, springs a short perpendicular lever. Between the free extremity of this lever, and the upper arm-trough, at the place of junction with the lateral steel-band, extends a vulcanised india-rubber band. The strength of the elastic band, in conjunction with its fellow, is so arranged as to keep the arm bent, except when the limb is voluntarily extended, the extensor muscles acting normally. This apparatus, whilst obviating the most immediate and distressing inconvenience arising from this form of paralysis, serves also as an important agent for facilitating the restoration of power in the paralysed muscles. For by its aid the patient may systematically practice a series of localised movements, one of the most important methods which can be adopted for re-invigorating debilitated or palsied muscles, flexion being brought about by the elastic cords. (Fig. 40.)

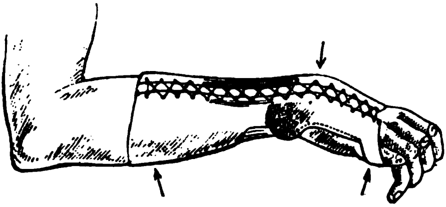
3. *Drop-wrist.*—This troublesome affection, arising from paralysis of the extensors of the hand, is chiefly a result of "lead-poisoning," and

FIG. 40.



is most common among painters and brass-founders. When it has not yielded to ordinary remedies, sometimes considerable relief may be obtained by mechanical agency. The unopposed and contracted flexors may be antagonised and the hand raised, either by the use of a helical spring or of vulcanised elastic bands. The latter are preferable, and in the accompanying diagram

FIG. 41.

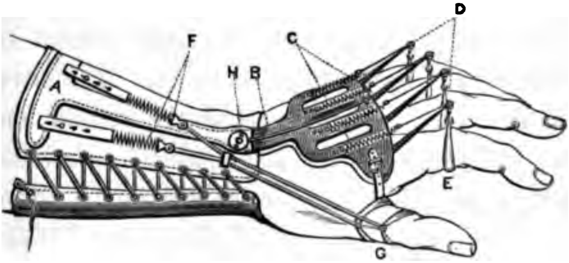


(Fig. 41) an arrangement is shown by which the elastic material may be applied effectively to the relief of this form of debility. With the use of this mitten, control over the knife and fork, a stick, or artificer's tool has been obtained.

4. *Contracted Fingers.*—The deformity resulting from contraction of the fingers, whether arising from paralysis of the common extensor of the fingers or of the interossei, is often considerable. Paralysis of the common extensor of the fingers is a frequent result of lead poisoning. This muscle extends the first phalanx of the fingers, and contributes to the extension of the wrist. When paralysed, the first phalanges cannot be elevated upon the metacarpal bones. The interossei flex the first, and extend the second and third phalanges. They also abduct, or adduct the fingers. The lumbricales aid in the extension of the first and second phalanges. When these muscles are paralysed, the first phalanx is tilted up by the want of antagonism to the action of the common extensor of the fingers, while the second and third phalanges are drawn downwards, the hand assuming that claw-like deformity which has been designated by French writers the "*main en griffe.*"

Mechanical aid is too frequently the only means which can be had recourse to for the relief of the deformities described. Several very ingenious instruments have been devised for this purpose by French mechanicians. The following gauntlet (Fig. 42) has been fabricated, according to the instructions of M. Duchenne (de Boulogne), by M. Charriere (after a model originally designed by M. Delacroix), for the relief of the deformity arising from paralysis of the common extensor of the fingers.

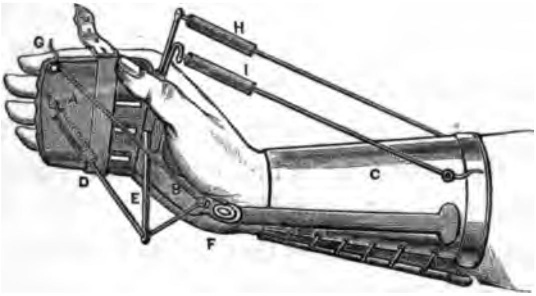
Fig. 42.



A, a metallic plate fixed at the posterior part of a wristband. B, a metallic plate articulated at H with the plate A in such a manner as to permit only lateral movements of the hand, to which it is attached by means of a leather-strap which embraces the palm, when the extensors of the hand are paralysed. If these muscles have retained their movements, an articulation fixed at B permits voluntary flexion and extension. From the inferior extremity of the plate B, rigid rods, somewhat raised, extend to the inferior extremity of the first phalanges. At the extremity of these rods little pulleys (D) are fixed, upon which run cords fixed, at one extremity, to the rings E, which embrace the ends of the first phalanges, and at the other to the springs C, which are attached to the dorsal plate. To the rings G, which embrace the thumb, are attached the springs F which arise from the metallic plate of the forearm.

The following drawing (Fig. 43) depicts an instrument invented by M. Duchenne, and fabricated by M. Charriere, to remedy the distortion arising from paralysis of the interossei muscles.

FIG. 43.



In the advanced stages of this deformity, the first phalanges are to some extent subluxated upon the metacarpal bones, and the metacarpophalangeal articulations are very rigid.

The instrument is composed of three chief pieces. A, the digital; B, the palmar; and C, the anti-brachial. These three pieces are articulated, as shown in the drawing. The digital portion is a plate having upon one of its faces four grooves destined to receive the fingers, and to maintain, by the aid of a leather-strap which presses the dorsal face, the last two articulations extended. The second plate (B) is applied to the palm. This plate is attached to a metallic splint, which is fixed to the anterior surface of the forearm. A strong spring is fixed by one extremity to the digital plate (A), and terminates by a gut-cord, which passes over a bridge (E) four centimetres in height, and through a ring fixed upon the palmar portion, is reflected and tied at the point G of the plate A. This cord is gradually tightened, so that the digital portion (A), that is to say, the first phalanges are inclined towards the plate B.

M. Duchenne states that he has effected many cures with this apparatus.

5. *Writers' Cramp, &c.*—This most troublesome malady is rarely alleviated except by me-

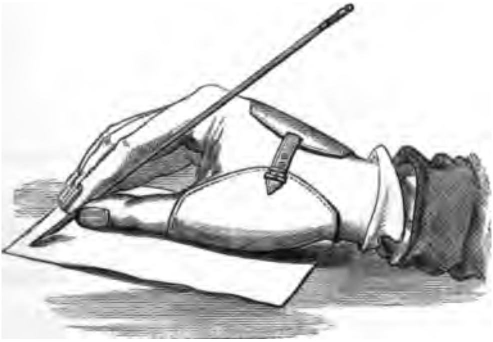
chanical means. Any other form of treatment is, as a rule, ineffectual. The disease consists in an uncontrollable spasm of certain of the flexor muscles of the hand, especially the flexors of the thumb, and the index and middle fingers. On attempting to write, the thumb is forcibly drawn into the palm of the hand, and the fingers named are thrown into irregular spasmodic action, and a wild scrawl is the result. Sometimes contractions of the muscles of the forearm are superadded, and occasionally various abnormal sensations attend the spasm. The musician, the sempstress, the shoemaker, and the compositor, are liable to be attacked with cramp of the same character and experienced in the same muscles. It is, however, chiefly observed among clerks. The affection is serious on account of its incapacitating the sufferer from pursuing his accustomed avocations, its persistency, and the little effect which remedies exercise upon it. By mechanical means, however, great relief may often be obtained, and some degree of control over the pen, the awl, or the type again secured. The case of the musician and the sempstress is less hopeful, but not hopeless. The intricate combination of movements required by the musician to command his instrument, and the exquisite co-ordination required by the sempstress to manage her needle, are fatally disturbed even by a trivial impediment to motion, and spasm is checked mechanically only by limiting motion.

The more the cramp is localised, the greater the chance of relief. When it chiefly affects the thumb the probability of complete, or at least, great amelioration approaches almost to certainty. Commonly, it is attempted to antagonise the muscles affected with spasm by springs so graduated as to resist the abnormal action. Latterly it has seemed to me that when the spasm is confined to the thumb, or the index and middle fingers, the best course was to fix the affected parts, and educate the unaffected fingers to work up (so to speak) to the affected. This can readily be done. Thus the thumb being the seat of spasm, it is fixed in a straight position by a well-moulded shield of gutta-percha, the last phalanx being free. The chief movements in writing, compositors' work, and shoemaking, are thus restricted to the fingers. The same principle is carried into operation when the spasm is mainly confined to the index and middle finger; and it may also be beneficially applied when both the thumb and index and middle fingers are affected with spasm. By fixing the parts liable to cramp, the tendency to spasmodic action of the muscles is diminished and the spasm itself restricted in degree.

An important advantage of the plan thus described is the inexpensiveness and simplicity of the mechanism. It is on this account well calculated to supply the needs of the class of persons who suffer most from the disease, and to encourage a wider adoption of its mechanical treatment in hospitals.

The accompanying diagram (Fig. 44) shows the application of the principle in an ordinary case of writers' cramp.

FIG. 44.



Other plans have been devised for the relief of this malady. M. Velpeau, for example, suggested a pear-shaped handle carrying a tube for the reception of a pen. (Figs. 45, 46).

Fig. 45.

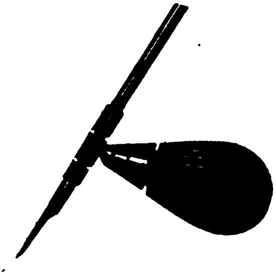
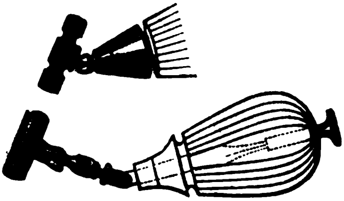
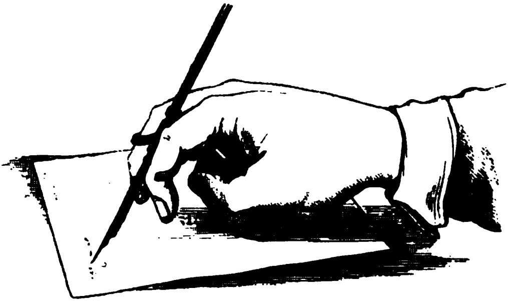


Fig. 46.



In certain cases rests for the fingers are added. (Fig. 47.)

FIG. 47.



GYMNASTICS OF THE UPPER EXTREMITY.

Gymnastics play an important part in the treatment of deformities and debilities of the upper extremity. Systematic, passive, or active movements, together with kneading and friction, are required in almost all cases of contraction of the shoulders, the elbow, and the wrist, and in paralysed states of the arm. By the latter means the nutrition of the muscles is maintained; by the former their functions and obedience to the will are gradually restored. Even where the entire flexors of a paralysed limb are more or less contracted from severe irritative lesion of the nervous centres, the contraction may be much ameliorated by a careful use of kneading and *passive movements.*

In carrying out passive movements the operator should quietly, steadily, and persistently endeavour to restore the normal movements of the articulation when contracted, or of the limb when paralysed. To effect this object, he must have in mind a clear conception of the nature and extent of motion of the different joints. To facilitate this aim I append the following brief synopsis of the mechanism of the different articulations of the upper extremity.

1. *Shoulder-joint.*—This articulation has the greatest range of movements of all the articulations. It permits motion in the following directions:—

(*a.*) *Before* (*flexion*).
(*b.*) *Behind* (*extension*).
(*c.*) *Abduction.*
(*d.*) *Adduction.*
(*e.*) *Circumduction.*
(*f.*) *Rotation.*

The movements forwards and backwards correspond to the flexion and extension of other articulations. The forward movement is very extensive, the arm, at will, being carried before and upwards to a vertical position. The backward movement is less extensive, and is limited by the head of the humerus impinging upon the coracoid apophysis. The shoulder-blade, it is requisite to note, is carried forward in extended movements of the arm anteriorly, executing at the moment a species of rotation. Abduction is the most remarkable movement of the articulation. It is peculiar to animals with clavicles. This movement may be carried out until the arm rests against the head. Adduction is limited by the thorax. Circumduction is the passage of the foregoing movements one into the other. In rotation the humerus does not turn upon its axis, but rather upon a fictitious axis passing in a line from the head of the bone to the interval condyle.

2. *Elbow.*—Two articulations enter into the formation of the elbow-joint, the articulation between the humerus and the ulna (humero-cubital) and the articulation between the radius and the ulna (radio-cubital).

The Humero-cubital articulation permits:

(*a.*) *Flexion.*
(*b.*) *Extension.*

The Radio-cubital (superior) articulation permits:

(*a.*) *Pronation.*
(*b.*) *Supination.*

The humero-cubital articulation has no appreciable lateral movement. The radius alone takes part in the movements of pronation and supination, the ulna being at rest. (Cruveilhier.) In these movements the bone at its inferior articulation with the ulna (*inferior radio-cubital*), does not, as at its superior articulation, turn upon its own axis by a true rotatory movement. It turns, indeed, round the little head of the ulna by a movement of circumduction.

3. *Wrist.*—The radio-carpal articulation has four movements:

1. *Flexion.*
2. *Extension.*
3. *Adduction.*
4. *Abduction.*

The movement of *circumduction* observed in the articulation is but the successive passage, one into the other, of the movements mentioned.

4. *Carpus.*—The bones of the same row have scarcely an appreciable motion the one upon the other.

The movements of one row of bones upon the other is more manifest, and consists in—

(*a.*) *Extension* (limited).
(*b.*) *Flexion* (less limited).

5. *Carpo-metacarpal articulations.*—The mobility of the different metacarpal bones differs.

The Articulation of the first metacarpal bone with the trapezium permits—

(*a.*) *Flexion.*
(*b.*) *Extension.*
(*c.*) *Abduction.*
(*d.*) *Adduction.*

The *flexion* is not direct, but oblique. This motion constitutes the movement of *opposition* which is characteristic of the hand.

Articulation of the fifth metacarpal with the cruciform. This articulation presents a vestige of the movements of the first, and it is so intimately allied with the *fourth metacarpal* that the latter partakes in its motions.

The carpal articulations of the second and third metacarpals have the immobility of symphyses.

6. *Fingers.* — *Metacarpo-phalangeal articulations:*—

(*a.*) *Extension.*
(*b.*) *Flexion.*
(*c.*) *Abduction.*
(*d.*) *Adduction.*
(*e.*) *Circumduction.*

In the metacarpo-phalangeal articulation of the thumb the extension does not pass backwards beyond the straight line of the articulation, as in the fingers.

Phalangeal Articulations :—

(*a.*) *Flexion.*
(*b.*) *Extension.*

The *flexion* of the second phalanx upon the first is as great as possible. The flexion of the third on the second is less extended. The *extension* of the second phalanx upon the first and that of the third upon the second are limited, and does not pass beyond the straight line.

Cruveilhier has described each finger as an entire extremity in epitome. The fingers, by their articulations with the metacarpus, are capable of movement in every direction and of circumduction; by the articulations of the phalanges between themselves, they possess the power of energetic, extended, and precise flexion ; and by the double movement of flexion of the second phalanx upon the first, and the third upon the second, they represent a true hook, seizing objects and grasping them firmly.

The muscles, so far as these may be affected by passive movements, follow the motions of the joints.

In carrying out passive movements in cases of paralysis it is important to induce the patient to attempt to aid the muscular action by voluntary effort. He must endeavour to supplement the extrinsic help by the exercise of his will. It is not sufficient for the operator to place the limb through different movements, the patient's mind, so to speak, must be *coaxed back into the paralysed limb*. This is often wearisome in the extreme to the patient, and repulsive from its seeming inutility, but it is essential to the efficiency of the treatment.

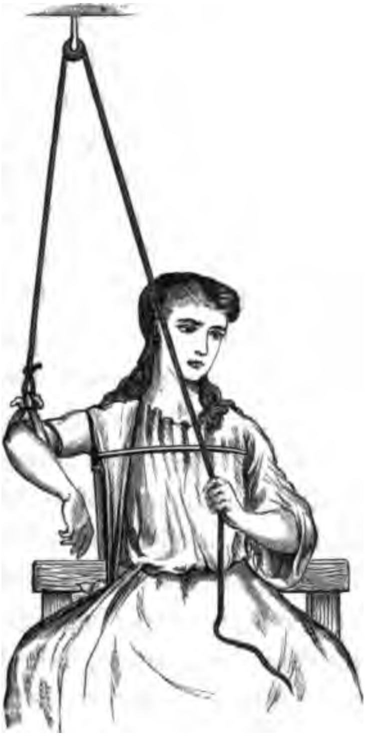
No arbitrary rule can be laid down as to the duration of each application of passive movements. In cases of paralysis, when the patient's volition has to be called into play, the earlier operations should not extend over many minutes, the time being lengthened as power is gained and the fatigue of the task diminishes. In contracted joints it is also a good rule to begin with a brief period and extend the duration of the movements as the case advances.

Another important point to give heed to is to make the movements rhythmical.

When a certain degree of voluntary power remains this must be turned to use and fostered, whether in the treatment of paralysis or contraction. This is best done by certain arrangements of pullies and weights, which would enable the patient by his own exertions frequently to develope the power which he possesses. In cases of contracted joints this may be effected by fixing a pulley in such a position as would enable the patient, by means of a rope passed through it, to bring a definite force to bear upon the offending articulation. The following drawing, after Bonnet (Fig. 48) shows an arrangement of this kind for obtaining motion in a contracted shoulder.

The shoulder-blade is fixed by a bandage passed over the shoulder and another round the chest beneath the arm-pits, while the patient exercises traction on the shoulder by means of a rope, attached above the elbow, and passed through a pulley fixed above him. Motion in any direction may be obtained by similar means, the position of the pulley being altered so as to meet the requirements of the case.

Fig. 48.



III.—Deficiencies.

From the time of Ambrose Paré the ingenuity of mechanical therapeutists has been incited in the highest degree to provide substitutes for limbs lost by accident or removed by operation. Their skill has been most severely tasked by the construction of artificial arms and hands. The wonderful mechanism of the hand, Sir Charles Bell believed to be characteristic of man. The mechanist might justly despair of imitating in any degree the action of the thumb, and its perfect opposition to the fingers. Ambrose Paré, as was shown in the Introduction, boldly attempted to solve some portion of the problem. He devised an arm and hand of iron in which provision was roughly but ingeniously made for flexion of the elbow and fingers. Many years passed before Paré's conceptions were much surpassed. The celebrated artificial iron hand of Gotz von Berlichingen, made by a mechanician of Nuremberg, and which was soconstructed that a sword might be held in it, differed principally in weight from that invented by Paré. It was not, indeed, until the beginning of the present century that mechanical skill showed itself equal to the fabrication of a hand by which an approximation to several movements of the natural member could be obtained. M. Baillif, of Berlin, was the first to construct an artificial hand which, without the aid of the normal hand, could seize and retain an object.

Paré's artificial hand was so heavy that it could only be worn for short periods. The iron hand of Gotz von Berlichingen weighed three pounds. The hand of M. Baillif did not exceed one pound in weight. Moreover, the fingers of the latter hand, in addition to the simple movements of flexion and extension, could be closed upon light objects, such as cloth, leather, a hat, and even a pen.

The great advance made by M. Baillif stimulated mechanicians in other parts of Europe. Many improvements were made upon his design. The external aspect of the arm and hand was more accurately obtained. A greater degree of firmness was gained in the mechanism without any sacrifice of lightness, indeed with a further diminution of weight. The methods, moreover, by which motion was secured in the elbow, the wrist, and the fingers, were simplified and refined. Artificial hands are now constructed by means of which a pin may be picked up from the ground, a glass raised to the lips, food carried to the mouth, and a sword drawn from its scabbard and held with tolerable firmness; while a combined arm and hand is fabricated which is equal to the ordinary requirements of histrionic declamation.

But it must be confessed that the most elaborately devised artificial upper extremity is a poor substitute for the natural limb. Its movements, as has been aptly said, approximate to the latter only so closely as the movements of a separated bird's claws, caused by traction upon the tendons by children at play, approximates to the natural motions. The highest flight of human ingenuity lags immeasurably behind the living type which it may seek to compass. The craftsman's art is limited, but it is not therefore the less commendable, and rarely has greater mechanical skill and ingenuity been displayed than in the construction of artificial arms and hands.

The expense of fabrication of the most elaborately designed artificial limbs, and the delicacy of their arrangements, must ever restrict their use to the wealthy. It is fortunate, however, that every practical object to which an artificial hand may prove subservient, can be obtained at a slight cost. A well-modelled, very useful, and comparatively inexpensive arm and hand can be fabricated.

I shall describe first the simpler forms of artificial arms and hands, and subsequently note, at greater or less length, the more elaborate mechanisms which have been devised as substitutes for a missing upper extremity.

It is necessary to premise that the form of stump is of considerable importance in the adaptation of an artificial arm. A stump above the elbow is best suited for this purpose when it gradually tapers from the shoulder to its lower end, and terminates there in a rounded surface. Too great an amount of stump, or a stump tapering rapidly to its extremity, present considerable difficulties to the mechanician. When the arm is removed at the shoulder-joint no stump is left by which an artificial arm can be attached, and the latter is fixed in its place by means of a corset.

In amputation below the elbow the best stump for the attachment of an artificial arm and hand includes two thirds of the fore-arm. This stump is sufficiently long to enable an individual to move with great freedom the artificial substitute, while it is not so long as to interfere with the mechanism which governs the action of the wrist-joint and hand. A stump formed by amputation at the wrist almost prevents the formation of a satisfactory artificial wrist.

The simplest apparatus which has been devised to supply the loss of an arm above the elbow, consists of a leathern sheath accurately fitted to the upper part of the stump. The lower end of the sheath is furnished with a wooden block and metal screw-plate, to which can be attached a fork for holding meat, a knife for cutting food, or a hook for carrying a weight. It has been customary to make artificial arms of this description *straight* (Fig. 49), thus giving to them a needlessly awkward and stiff appearance. I have been for some time in the habit of making this variety of arm curved (Fig. 50), adapting its curve to the

Fig. 49.

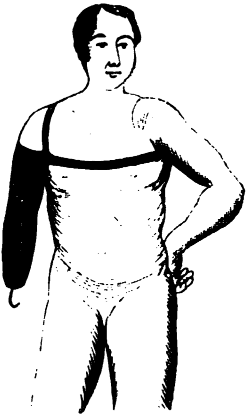
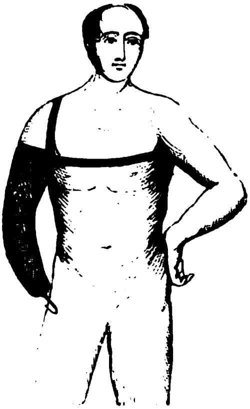


Fig. 50.



line of direction most commonly assumed by the natural limb when at rest. By so doing, the awkward and rigid aspect of the mechanism is largely removed. The artificial limb is retained in position by shoulder and breast straps, as seen in the figures, and it forms a very handy, light, useful, and inexpensive substitute for the missing member.

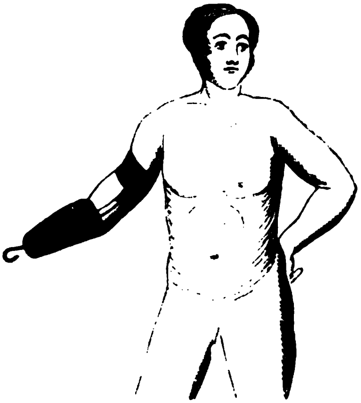
By giving to an arm constructed as above angular motion at the position of the elbow a more useful, and still inexpensive, piece of mechanism is obtained. A more shapely apparatus is made by the substitution of a wooden hand for the steel disc at the free extremity (Fig. 52). The action of the joint is regulated by a ratchet and cog-wheel concealed within the sheath at the point of flexion, movement being impressed by the hand still retained. The motion of the joint is limited by a small spring button placed on the inner side, a little above the point of bending (Fig. 50).

The advantages arising from these modifications of the common artificial arm are great. Its appearance is thereby greatly improved; it admits of certain articles—as, for example, a cloak—being carried upon the forearm; and it largely facilitates the adaptation of the arm to the various practical purposes to which it can be applied.

When the arm has been removed at the shoulder-joint the artificial substitute is fixed in its place by means of a soft leather cap, which envelopes the whole of the top of the shoulder, and extends to the breast-bone in front and the spine behind: to this cap the artificial arm is attached.

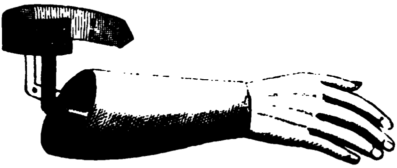
The common arm below the elbow is also formed of a sheath accurately moulded to the p, with disc or wooden hand attached. t care is required in fitting the sheath to the

Fig. 51.



remnant of the forearm, in order that, on the one hand, the motion of the latter should not be impaired, and that, on the other, the former should retain its position when affixed. Care is also required to avoid pressure upon the extremity of the stump. When two thirds of the forearm are left a well-fitting sheath can be kept firmly in its place by two lateral straps attached to a padded band which passes round the upper arm (Fig. 51). If the stump be short and a firmer attachment is needed, this is provided by a padded metal band encircling the upper arm, and attached to the sheath by two lateral metal stems, pointed at the elbow (Fig. 52).

FIG. 52.



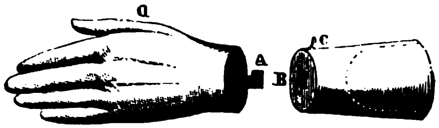
The orthopractic mechanician is sometimes required to make good the deficiency of two or more fingers. Surgeons, now-a-days, in injuries of the hand which formerly led to amputation of the forearm, will frequently remove the injured parts solely, and preserve the patient a useful thumb or a leash or more of fingers. Some of the happiest results of "conservative surgery" have been shown in injuries of the hands. It is more difficult to devise a satisfactory substitute for missing fingers than for an entire hand, but it can be accomplished. For example, if the thumb alone be preserved, a leather sheath is accurately moulded to the stump, including the wrist and a portion of the forearm, an aperture being left for the thumb to pass through. To this sheath carefully designed fingers and such portion of the hand as is wanting are attached. This plan, modified according to the circumstances of the case, is adapted to the different forms of stump resulting from partial amputation of the hand.

The next advance in the construction of an artificial upper extremity is to give motion to the fingers. The hand previously described does not possess motion either at the wrist or the fingers. It constitutes an advance upon the common stump arm, but its want of flexibility detracts greatly from that gracefulness of aspect which is desired when symmetry is regarded as of equal importance with practical utility.

On contemplating the fingers of the natural hand, it is observed that the mechanical form of the joints is what is technically termed ginglymoid or hinged. If the hand be made to grasp a globular surface rather larger than its own concavity, the fingers will be seen to expand laterally. Rightly to imitate the motion of the fingers, the mechanician should endeavour to obtain these two movements, namely, angular motion in the same plane as the fingers move downwards, and lateral motion at right angles to such a plane. There is but one form of artificial joint, the ball and socket, which admits of motion in more than one plane at the same moment; and this form of joint, from the impossibility of maintaining a proper control over its movement, is inadmissible to the construction of artificial fingers. One form of joint, therefore, can alone be adopted, the hinged, the axis of movement being arranged so as to correspond with those of the natural hand. A like form of joint admits of the lateral action of the thumb being obtained, while by means of a spring fixed between the thumb and first finger the former is more accurately approximated to the fingers.

The wrist plays an important part in every motion of the hand, and its action must, in some degree, be simulated in the mechanical substitutes. The wrist has lateral, rotatory, and ginglymoid motion. In the class of hand under consideration these movements are imitated in the following manner. The extremity of the artificial forearm or wrist-cap and the upper extremity of the hand are furnished with metal discs. The disc attached to the hand carries a "key-hole plug." The disc attached to the forearm has an aperture for the reception of the plug. When joined to the arm disc, the wrist can be turned completely round (Fig. 53, A, B). A small spring (C), acting against a certain number

Fig. 53.



of holes or depressions in the wrist-plate limits, however, the amount of circular motion, and permits the hand to be fixed in any position (Fig. 53, D). The ginglymoid action of the wrist is obtained by a joint composed of a shallow cup and semispherical tenon, the centre of which is secured by a pin passing from the wrist-plate.

By fixing a spring within the centre of the thumb, a sufficient amount of pressure is exercised between the thumb and forefinger to admit of a pen being manipulated, a neckerchief tied, &c.

The flexibility of the natural hand being thus to some extent imitated, it is desirable to impart to the substitute some degree of the softness characteristic of the living member. This has been sought to be done by a covering of gutta percha and india-rubber. By this course the hardness of the artificial hand is rendered less obnoxious to the touch, but it does not deceive the fingers.

A hand thus constructed, when the fingers are placed in a natural position, leaves nothing to be desired in the way of symmetry. Often, indeed, the artificial hand is more symmetrical in aspect than the natural, and, in a spirit of coquetry, the gloved substitute is frequently displayed in preference to the real hand. But such a hand possesses no grasping power, excepting only the feeble pressure already mentioned between the thumb and the finger. Provision has, therefore, to be made for attaching instruments to its palm, similar in character to those made in the common stump arm. The hand, indeed, acts as an elegant shield for the mechanism by which various instruments are held.

This mechanism, and some of its applications, is shown in the following illustrations.

FIG. 54.

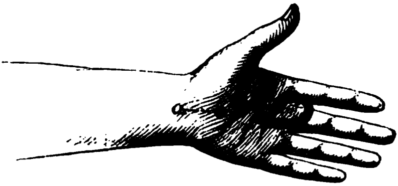
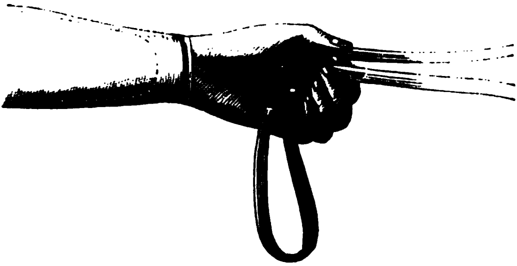


Fig. 54 represents a simple hook with spring fastening, by which it can be secured to the palm of the hand and removed from it at pleasure.

The office of the hook is important, enabling the artificial hand to fulfil any act of ordinary lifting, &c. There are various modifications of the hook, such as the driving hook (Fig. 55), composed of a double tenaculum, which admits of reins being separated, and thus held in the same position as they would be by the natural fingers.

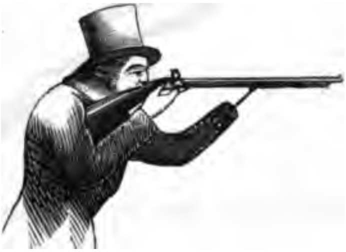
Loss of the hand by the explosion of a gun

FIG. 55.



occasionally occurs, and it happens sometimes that the accident does not quench the desire of the sportsman for a renewal of his amusement. This desire, when the right hand still remains, is easily accomplished by affixing to an artificial hand a hook so shaped as to hold the barrel of the gun (Fig. 56).

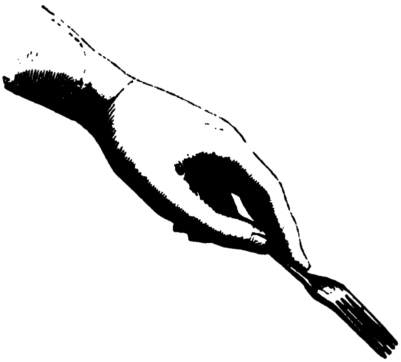
FIG. 56.



Another kind of hook is one capable of being fastened to the arm-plate. This is intended for lifting heavy weights, as, being used when the artificial hand is removed, the whole stress is borne by the muscles of the arm.

Amongst the instruments to be adapted to an artificial arm the knife and the fork (Fig. 57) hold the foremost place. When a stump is short a certain amount of difficulty occurs to the patient in getting the fork to the mouth, but this can be easily overcome if a particular set or shape be given to its stem.

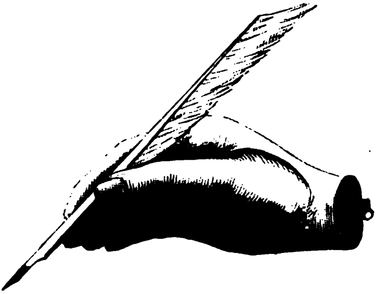
Fig. 57.



If the right hand be lost, it is necessary to furnish some mechanical means for enabling the wearer of an artificial arm to employ his pen.

For this purpose, a metal holder inserted into the palm of the hand has been devised, and by its aid the patient can grasp a pen with sufficient power to write tolerably well.

Fig. 58.



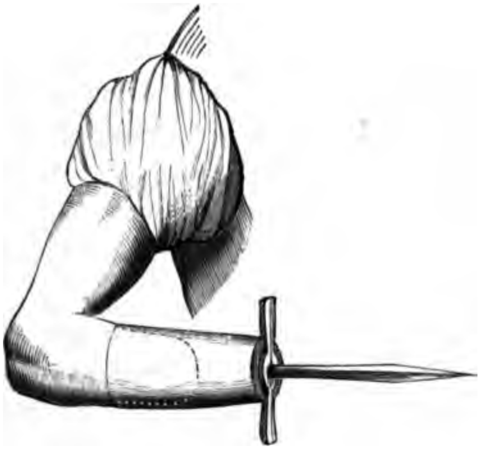
If, however, the hand has a spring thumb, the penholder is not so much required, as the first and second fingers hold a pen (Fig. 58) pressed against them by the thumb sufficiently well to impress its marks upon paper, and to admit of tolerably fine writing.

A brush for cleansing the nails can also be attached to the palm of the hand, as likewise a file with penknife at its extremity, the blade of which, standing rectangularly to the surface of the file, enables the nails of the natural fingers to be easily pared.

For horticultural purposes a pruning knife is occasionally appended, as also a ring for holding the handle of a hoe or rake. This latter apparatus being made with three joints, permits of the rake handle being moved in any direction.

A few years since, the writer was requested by a patient, a fur collector for the Hudson's Bay Company, to fit the stump of his right forearm with a dagger. The following is a drawing of the weapon and its mode of attachment.

FIG. 59.



The number and variety of instruments capable of being applied to an artificial hand scarcely admits of limit. A sufficient idea of the method of application may be gathered from the preceding woodcuts.

The construction of an artificial upper extremity has now been sketched from the simplest model to the simulation of the different joints of the arm and hand, and the accurate representation of external form. The joints possess no motion except such as is impressed upon them from without. The artificial arm and hand thus constructed is dependent chiefly upon the manipulation of the upper extremity which still remains intact for its utility. Human ingenuity has not, however, rested contented with this success. It has ventured, as previously stated, upon higher flights. It has endeavoured to give to the artificial joints certain movements independent of any agency of the remaining hand. It has striven, indeed, to impart to the fabricated limb, through the agency of the stump, certain of the most important movements of the natural limb. With what success this object has been pursued will presently be seen.

The means by which apparently independent and, as it were, voluntary movements are attempted to be carried out are comparatively simple, but their application is most difficult, demanding the extremest nicety of construction. A cord of gut, having one extremity fixed to the shaft of the artificial arm or to the trunk, and passing over sundry pulleys, represents the complex muscles and tendons of the living arm and hand in one form of apparatus; an endless screw attached to the end of the stump, with or without the aid of gut cords, represent them in another.

Some years since I devised a hand which, by a series of concealed cords and springs, possessed the power of grasping and retaining, with some slight amount of force, any light substance placed in contact with it, the governing power being the fall of a small column of mercury placed in a tube within the arm part of the apparatus. The object I had in view was that, the elbow being flexed, and the lower arm placed at an inclined plane, the gravity of the quicksilver acting upon a kind of plug to which the centre cord was attached, should at once produce a closure of the fingers, whilst the return of the mercury to the lower end of the tube, upon the arm being lowered, would permit slight springs to brink back the fingers to their original starting-point. This plan did not succeed, as the joints had to be made so loose that they gained lateral motion, thus giving anything but a natural appearance to the fingers, and the metal, in spite of every care taken to secure it, continually escaping, rendered useless the contrivance.

The artificial arm and hand constructed by Mr. Baillif, of Berlin, has been already referred to. Flexion of the fingers was produced by strings passing from one phalanx to another; extension was secured by gut cords connected with the fingers, and attached to the superior border of the sheath. By the extension of these cords the contracting force of the springs was overcome.

In 1845 an artificial arm and hand was constructed by a young Prussian mechanician, M. Van Petersen, of extraordinary ingenuity. M. Rogers, the celebrated French tenor, had lost his right arm above the elbow. He would be unable again to tread the boards of the opera unless a substitute could be devised which would serve the purposes of histrionic declamation and permit him to grasp and draw a sword from its scabbard. The need of the great vocalist set the orthopractic ingenuity of France on the stretch; but the honour of first designing an artificial arm and hand which fulfilled the objects sought rests with M. Van Petersen.

The following account of M. Van Petersen's artificial arm is derived from a report of the Academy of Sciences. The commissioners were MM. Gambey, Rayer, Velpeau, and Magendie, the latter being the reporter.

M. Van Petersen's arm is not adapted indifferently for all who have been deprived of an upper limb. It is fitted for those alone who possess a good, perfectly mobile, and sufficiently lengthy stump. Free motion of the shoulder-joint and good leverage are the fundamental considerations which have governed the construction of the limb, and they are requisite to its proper action.

The artificial arm consists of three articulated parts, representing the wrist, fore arm, and hand. The latter consists of a kind of carpus and of movable fingers of three phalanges, maintained in persistent flexion, and of opposition to the thumb, by springs. The entire weight barely exceeds 17½ ounces avoirdupois.

The stump is received in an excavation of the apparatus, and is fixed firmly there by straps, so that every movement which can be executed by it, above, below, within, without, before, and behind, is readily transmitted to the mechanism. But this was not the chief difficulty to be overcome. The one-armed have fixed a stick or hook to their stump, and used it with address.

The true difficulty arose in making the different portions of the apparatus play the one upon the other, so that the reciprocal movement of the forearm upon the arm, the hand upon the forearm, and the fingers upon themselves, could be simulated. This complicated result, indispensable for the reproduction of some usages of the arm and hand, M. Van Petersen obtained in the following manner:—A corset is applied to the chest; to this corset are attached gut cords which elsewhere are fixed, some to the forearm, others to the fingers. When the stump is moved forwards, by means of the gut cords traction is brought to bear upon the forearm, which is flexed upon the arm. When, on the contrary, the stump is carried backwards, the forearm is extended and recedes from the arm. By this double movement the artificial hand can be carried to the mouth at the will of the wearer.

The movements of the fingers requisite for grasping objects are produced by an analogous and not less ingenious arrangement. Cords, fixed by one extremity to the corset, are attached by the other to the dorsal side of the flexed fingers. When the stump is moved outwardly it acts upon the cords, the resistance of the springs is overcome, the fingers extended, and the hand opened. In order to grasp, the wearer has only to direct the hand thus opened to the object; he next gently brings back the stump towards the trunk; the tension of the cords upon the springs being thus removed, the fingers close upon the object, which is held with all the more firmness because each of the fingers acts independently of the others and presses firmly on the surface with which it is in contact. The object being grasped, the rest of the action depends upon the springs.

To direct the arm to the mouth, the stump is carried forwards, the forearm flexes, and the hand arrives quickly at its destination.

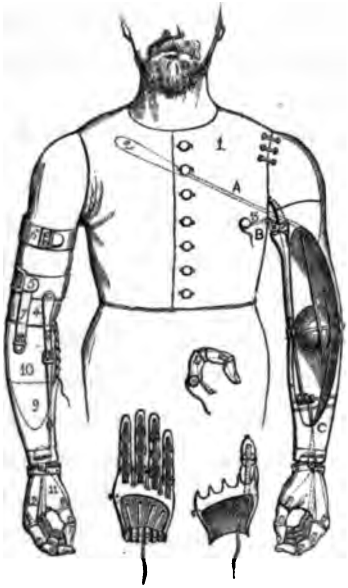
In order to release the object, and replace it, for example, on the table, the stump is moved backwards, by which means the forearm is extended, when the stump is carried outwards this movement causing extension of the fingers and the abandonment of the object which had been grasped.

Practice is required before the arm and hand can be used with dexterity, but it is surprising how quickly a mastery of the mechanism is obtained. Gloved and covered with a sleeve, Van Petersen's arm is not easily distinguished from the natural member, particularly if the wearer carry it with address.

The commissioners point out that the idea of taking a fixed point from a corset attached to the trunk for the purpose of overcoming the resistance of mechanical fingers, closed by springs, was not novel. It was partially carried out during the first quarter of the sixteenth century, by a Nuremberg mechanician. It was adopted also by M. Baillif, of Berlin, and still more recently by Graefe. But the first person who gave a true practical developement to this idea, and showed its actual value, was M. Van Petersen.

The Commissioners tested the worth of M. Van Petersen's invention upon a soldier who had lost both arms. By its aid he was enabled to pick up a pin, take hold of a leaf of paper, &c. "Judge," say they, "of the joy of this veteran, when, after thirty years' absolute privation, he found himself, all at once, able to execute these actions, imperfectly, no doubt, but in such a fashion as once more to give him some of the agility of his younger days." The grief of the old man was so marked when the experiment ceased, and the artificial arms removed, that the commissioners suggested to the Academy the propriety of presenting him with the pair. This sug-

Fig. 60.



gestion was adopted, and the veteran made supremely happy. The adaptation of the arms in this case is shown in the accompanying cut (Fig. 60).

The conceptions of M. Van Petersen were very rapidly extended and improved. M. Charriere, the celebrated surgical mechanician of Paris, aided by M. Huguier, also constructed an artificial arm for M. Roger, of which the following is a description:

The apparatus is fixed to the stump by a laced armlet (Fig. 61), connected with the forearm by two metallic hinges. The upper edge of the armlet should be attached to a light shoulder-cap. This arrangement will prevent the armlet falling down when the forearm is extended, and it will obviate undue constriction of the stump, particularly if this be conical, as is often the case.

The forearm is made of prepared leather, and it terminates at the wrist by two springs, which permit flexion of the hand.

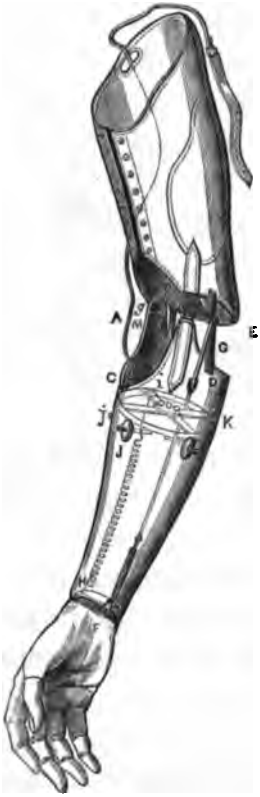
The hand is made of wood, much hollowed to diminish weight. The phalanges which form the fingers are made of steel, covered with wood, jointed in a peculiar fashion, and sufficiently firm to remain in any position in which they may be placed.

A gut cord (A) fixed to the forearm (C) acts upon the latter, taking its point of movement at the level of the shoulder, after the method of M. Van Petersen. By elevating the stump the elbow and wrist are flexed.

This movement acts upon a second cord (D), which is fixed to the excentric (E) of the elbow-hinge, the extremity of the cord, furnished with a strong spiral spring, being fixed in the hand at the point F, flexes it at the wrist. But the moment traction ceases upon the cord fixed behind the shoulder the forearm becomes straight by the force of two elastics (G G), placed behind the elbow. The wrist becomes straight at the same time as the forearm, by means of a spiral spring fixed behind the hand at point H, and the fore-arm at I.

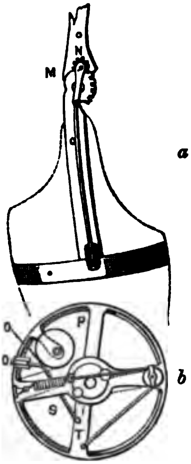
Pronation and supination of the artificial limb is obtained by one of the projections (J) placed on the forearm, below the junction (K) of the inferior and superior parts of this last. Movements of rotation can be executed at will by pushing with the hip or with the other hand one of the jutting points (J).

FIG. 61.



The mechanism for producing pronation and supination is as follows (Fig. 62):

FIG. 62.



The excentric M, by the addition of the gear N, can make an entire turn by complete flexion of the forearm.

In following this movement it is seen that, 1st, by flexion the excentric makes a half turn, draws upon the cord O, which works round the pully P

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* Fig. 62. *a.* Apparatus for flexion of the elbow, designed to act upon the cord by which pronation and supination is produced.

b. Section of the upper part of a forearm, with the mechanism for the production of pronation and supination by flexion of the elbow.

(Fig. 62), and at the point where it is attached (R) to the cross-bars of the lower part of the forearm where the hand is fixed, and which, drawing this over, produces the movement of supination during half the range of flexion of the forearm; 2nd, if the act of flexion is continued to its completion the excentric will continue to turn, and will redescend to its first position; then the cord lengthens, the spiral spring S, which is attached to the point T, and which has yielded to the traction of the first movement, shortens and brings back the hand into its first position by the movement of pronation.

The same movements of the hand are produced when the forearm is extended.

By the aid of this system flexion of the fingers can be produced.

About the same time that MM. Huguier and Charriere first fabricated the artificial arm of which the foregoing is a description, M. Bechard also constructed an upper extremity in which the different motions were produced by one cord of traction, and which also simulated the movements of pronation and supination.

The following is a description of M. Bechard's artificial arm and hand:

The point of support is a laced sheath carried by two iron splints adapted to the arm.

The articulation of the elbow presents nothing particular.

The forearm and hand consist of three movable pieces of hollow wood.

1st. The upper portion is fixed by means of the two splints which serve for the articulation of the elbow, and terminate there.

2nd. The second portion, entirely of wood, corresponds to the lower two thirds of the whole length; it carries at its upper part a movable chariot, rolling by means of bone castors, which slide on a circular plate of iron, so that the movements are very smooth. This arrangement allows this portion to move on the upper one through a quarter of a circle, and this motion, being transmitted to the whole lower part, simulates the rotation of the limb outwards.

The limb is maintained in the normal state of pronation by a spiral spring fixed, at the top of the piece, in the centre of the chariot, and the permanent action of which acquires all its force when all pulling ceases. To explain this mechanism more fully, a single cord of gut, starting from the top of this piece and communicating with the chariot by means of two small pulleys, goes up along the amputated limb, passes behind the shoulder, and reaches obliquely the circular band of the trousers, at the braces of the opposite hip.

When the arm is abducted this cord, being stretched, acts on the chariot, which, rotating on its axis for a quarter of a circle, carries with it all the lower part of the apparatus, rotating it outwards—that is to say, supinating it. When, on the contrary, abduction is replaced by adduction, the spiral spring we have mentioned gets in action, and brings back the arm by a reverse movement into the normal position—that is, pronation.

The second piece, which performs this movement of rotation over a quarter of a circle, carries in the centre of the upper plate which terminates it a straight rod, which descends through its interior in the direction of its axis. This rod, which, for a sufficient length, is surrounded by an endless screw, supports, on a level with that screw, a horizontal box, which it raises during supination and lowers during pronation. The box itself carries, at its extremities, two parallel branches of iron, which terminate a little above the wrist-joint in two transverse metallic button-holes. These button-holes enter a segment corresponding to each of them, cut out of the iron plate which terminates this second piece; they are connected with the pulling of the fingers. As the action of the endless screw on the box is manifested during rotation, the two branches which terminate it, rising during supination, act on the extensor tendons of the fingers and bring them into action.

The third improvement is much more important, and consists in this:—The hand which is at the end of the artificial arm, being exposed, when used, to all kinds of friction, gets easily dirty; and then it is necessary, according to circumstances, in order that the imitation be perfect, that it should be naked or gloved.

After a good many trials, M. Bechard discovered a method of unhooking the wrist by means of pressure, made with the other hand on a button hidden under the coat-sleeve. It will be easily conceived that much patience was required in order to succeed in combining a system admitting of the arm being completely taken to pieces, of changing the hand, and of instantaneously resembling the action of the extensor and flexor tendons. With this view, the union of the wrist with the second piece of the arm, the mechanism of which has been described, is effected a little above the place occupied by the radio-carpal joint below, by means of a double-toothed pinion entering a mortise hollowed out of the lower surface of the second brachial piece. On each side of this pinion are two prominent buttons, with conical heads above a smaller neck, which correspond to the pulleys of the fingers, divided into two bundles. Both parts are joined together by making the pinion obliquely enter the mortise; the wrist is then made to rotate over a quarter of a circle, in the same way as a bayonet is fixed, and when the rotation is completed the two metallic buttons come and hook into the two horizontal button-holes which terminate the two branches of the mobile screw-box indicated above.

Lastly, the fingers, carefully carved out of wood, show no mechanism externally; all is in the interior. M. Bechard does away with the cord of gut as the acting force, and with the spiral springs as the resisting force. A simple flexible steel plate, placed inside and half flexed, is arranged in such a manner that by pulling on the upper part it produces extension, and the reverse movement when it ceases to act. The thumb alone is moved (by means of two reflecting pulleys connecting it with the common traction) in such a manner that when the fingers are extended it performs the same movement, and is besides abducted in order to return to the flexed position, and is adducted when at rest. Furthermore, care has been taken, not only to put in its anatomical place the metacarpo-phalangeal articulation, but also to imitate the longitudinal grooves which separate them; this has never been done before, and detracted from the shape of the hand, rendering it unnatural and ungraceful. The idea of these two last innovations was suggested to M. Bechard by the Earl of Beaufort, who has given great attention to this subject.

To sum up, M. Bechard's arm, by means of a single point of traction, placed in pronation, executes first the movement of supination, next in succession the extension of the fingers and abduction of the thumb; the hand is then wide open.

The preceding description applies to an apparatus intended to replace the forearm amputated below the elbow.

If it is required to replace a limb amputated through the lower part of the humerus or through the elbow-joint, an armlet is added which embraces the upper part of the opposite arm. This arm-piece serves to give attachment to a traction string, which passes transversely from one shoulder to the other, and, after coming down along the apparatus, ends at the upper and inner part of the forearm. This string is destined to produce flexion of the elbow. It is moderately tense in the normal position of a man who is standing, and acts when the sound arm is abducted; on the two points of attachment becoming more distant the elbow is flexed.

Since the fabrication of the arms designed by MM. Van Petersen, Huguier and Charriere, and Bechard, different mechanicians have suggested sundry modifications of construction, and carried them out with more or less success. A detail of these variations would be of little interest, and for the most part they are of little value. The artificial arms which have been described have not yet been surpassed in beauty of execution and ingenuity of mechanism. It is not improbable that a more simply constructed, yet equally, nay, even more efficient artificial upper extremity may sooner or later be devised. I have been endeavouring for many months to devise so desirable an apparatus, and am hopeful of success. But the result must prove the work. Until the mechanism has been subjected to trial it would be idle to describe the modifications I am endeavouring to carry out.

CHAPTER III.

THE TRUNK.

I.—Deformities.

Abnormal *curvature of the spine and deflection of the pelvis* sum up the category of deformities of the trunk.

Spinal Curvature.

Distortion of the spine has engrossed professional and public attention to an extent which, on a hasty glance, might appear to be altogether disproportionate to its importance as compared with other deformities. It might seem that a distorted hand or foot would give rise to much greater evils than a morbidly curved spine. Wryness of a limb apparently is a more serious obstacle to bread-winning than wryness of the spine. If the magnitude of a deformity is to be estimated by its effects on the social well-being of an individual, surely those deformities which interfere with the just exercise of the members should hold the foremost place. It is not an easy task to determine the relative social importance of different forms of deformity. Each one of the deformed, as a rule, considers his own deformity to be the worst. Among the operative classes, unquestionably, a distorted arm or leg often is of greater consequence than a distorted spine. A slight deformity of a member limits the already too restricted fields of bread-winning occupation to a greater extent than a slight deformity of the trunk. With the artizan the magnitude of a deformity must be estimated by the degree in which it affects the means of gaining a subsistence. Here the deformity as a defect of symmetry, is a much less evil than as an impediment to utility.

Among the wealthier classes, on the other hand, the magnitude of the deformity is measured mainly by its influence on symmetry, and of all the varieties of deformity none so greatly detracts from the beauty of the human carriage as distortion of the spine. No lengthened argument is needed to show the pre-eminence of a symmetrical trunk in the conditions of human beauty. One illustration will be sufficient to prove this position. In the great museums of ancient art there are treasured *torsos* over which the sculptor and the artist dwell with inexhaustable rapture. Limbless, headless, these sculptured trunks are big with an indefinable grace and beauty which set at nought the ravages of time. The imagination, as the eye rests on the genius-wrought marble, readily supplies the wanting parts, and an inspired whole rather than a mutilated fragment occupies the mind.

Not such, however, is the effect produced by a sculptured head or limb. Both may enlist our admiration for their independent beauty, but neither the one nor the other enables us to build up in the imagination that exquisite carriage which is the distinguishing beauty of the human frame. This carriage is mainly due to the trunk; and the relation of the head and limbs to it, apart from the trunk, is slight. Half an hour's ramble among the ancient sculptures in the galleries of the British Museum, the Louvre, or the Vatican, would furnish abundant proof of this statement.

It is not surprising, then, that, as a defect of symmetry alone, distortion of the spine should have acquired precedence among deformities. Wryness of the vertebral column is fatal to the symmetry of the trunk and to that exquisite harmony of parts which constitutes the beauty of a sculptured *torso*. Often, also, spinal curvature is connected with deformity of the extremities; and when aggravated it renders the unhappy sufferer the most wretched of cripples.

The spine is to the osseous system what the heart is to the vascular and the brain to the nervous system. It is a general centre for the whole of the bony structures, all of which are developed in harmonious relation to it. If the opinions of our most learned anatomists be correct, a constituent segment of the spinal column—the individual vertebra—is the archetype of the entire vertebrate skeleton. The cranium and the upper extremities, the pelvis and the lower extremities, are, they say, modified vertebræ. According to this hypothesis the spinal column is the centre of the osseous system in a higher sense than is here sought to be conveyed.

The spine is a hollow bony column, sustaining nearly the entire skeleton, and forming the principal lever of the body. Running along the entire length of the trunk, the portions included in the neck, the chest, the loins, and the pelvis, have been designated respectively cervical, dorsal, lumbar, and sacral or pelvic. Omitting the sacral portion, the column is formed of twenty-four separate bones (vertebræ), arranged one above the other. Seven of the vertebræ are included in the cervical region, twelve in the dorsal, and five in the lumbar. These constitute the *true* vertebræ. The sacral portion is formed of nine vertebræ, five being united together to form one bone, the sacrum; four being rudimentary, constituting the coccyx, The last-named vertebræ are termed *false*.

The height of the spinal column varies at different ages. It increases from birth to the twenty-fifth year. Sometimes the increase stops before this age. In the adult the height is stationary, but a diminution occurs in old age, from inclination of the trunk forwards and some degree of atrophy of the intervertebral substances and bodies of the vertebræ.

Viewed sideways, the spine presents several alternate curves. These are four in number. The column arches forwards anteriorly in the cervical and lumbar regions and backwards to the dorsal and sacral. Thus, looking forwards, the column is convex in the neck and loins, concave in the back and pelvis. In the rear the curves are in an opposite direction to those viewed from the front. The first three curves have a direct dependence the one upon the other. For example, if the cervical convexity be more marked than common, the dorsal and lumbar curves will be found also to be more convex. The mutual relationship of the curves is such that the least modification of one brings about a corresponding modification in the others. Notwithstanding this, it has been found impossible to submit these curves in the living subject to a rigid calculation. The varying conditions of the living body set at defiance those exact measurements which can be applied to inorganic substances.

The mechanism of the spinal column is very wonderful. Singularly rigid in structure, it is nevertheless exceedingly light and possesses rare elasticity and pliancy—a combination of mechanical properties which man has in vain attempted to imitate. The numerous bones of which the column is built, while securing mobility, do not, against all human estimates of probability, sacrifice solidity. It happens, indeed, as Cruveilhier as shown, that the numerous articulations by which these vertebræ are connected are all seats of a decomposition of force when the spine is subjected to shocks. A portion of the movement impressed upon the column produces slight displacement of the articular surfaces, and this portion is entirely lost for the transmission of the shock. If the vertebral column were formed of one piece, a force impressed, being transmitted without any loss, would be much more apt to occasion injury to the structure of the nervous centre which it sheathes. The aptitude to suffer from shock is still further diminished, and the mobility of the column increased, by the interposition of a thick elastic cartilage between each pair of vertebræ.

The canal which traverses the column, for the reception of the spinal marrow, serves also the same purpose as the cylinder of the long bones, that is to say, it augments the resistance without augmenting the weight.

The alternate inflections of the column permit much greater variations of its centre of gravity than if the vertebræ had been arranged rectilinearly, while at the same time they increase the vertical motion.

The different vertebræ are firmly bound together by strong elastic ligaments, and the whole spine is *stayed*, so to speak, by numerous powerful muscles. The ligaments, by their great elasticity, incessantly struggle against those causes which tend to throw the column awry. They exercise also an important influence in maintaining the curves. But the ligaments and the wonderful articulation and construction of the spine would not, without the aid of the powerful muscles which occupy the grooves of the column, and are attached to its numerous processes, suffice for the maintenance of the erect position. The force of the muscles is exactly proportionate to the weight they have to overcome. Hence in health the act of standing occurs without perceptible effort. The erect position is not, however, a state of repose, as is shown by the sensation of fatigue in the lumbar region after long standing, and the relief afforded by resting the body forwards.

As an organ of support for the head and trunk, the spine has a solid base of sustentation at its junction with the pelvis. In whatever position the body may be placed, the spine at this point remains in a quiescent state.

When the spinal column is in motion the centre of gravity, according to the researches of Weber, is placed within the area of junction between the column and the pelvis, and it rarely rises more than a slight space above the point of attachment. Hence the equilibrium between the head and body is left almost undisturbed.

An ingenious writer, Mr. W. Adams,* has endeavoured to prove that the spine is held so evenly in equilibrium by the articulations of the osseous structures, that the muscles acting upon it are simply in a condition of " vigilant repose"—that is to say, they do not actively aid in maintaining the equilibrium of the trunk, but are ever ready to start into action when influenced by volition or by the different movements of the body. This may be true when the body is at ease in a chair or rests upon a support—as, for instance, lounging over a gate or upon a wall; but it is entirely incorrect when applied to the ordinary conditions of the erect position of the trunk. The equilibrium of the spine is constantly being disturbed by the acts of inspiration and respiration, even by the action of the heart; also by the multifarious movements almost unconsciously made by the body. The rectification of the incessantly disturbed equilibrium would be an impossibility were it not for the resilience of the spinal ligaments, and more especially for the active co-operation of the muscles. These, in the conditions referred to, are in a state of active tension, and not of passive vigilance. For example, in every act of inspiration the air rushing into and expanding the lungs alters the centre of gravity of the thorax in relation to the spinal column. The expanding force, acting upon the ribs is transferred also to the vertebral column, and tends to throw it out of equilibrium. But at the moment of inspiration the tractors of the spine enter into action, and neutralise the disturbing influence of the movements of the ribs, maintaining the equilibrium of the column. When morbid difficulty of breathing exists, as in asthma, the active co-operation of the spinal muscles in fixing the vertebral column is very apparent.

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* 'Lectures on the Pathology and Treatment of Lateral and other Forms of Curvatures of the Spine.' 8vo. London, 1865, p. 51, *et seq.*

It is probable, as Mr. Bishop maintains, that the erect position is that in which the *least* expenditure of muscular action occurs. But this proposition differs widely from the one under consideration. The theory of "vigilant repose" would not, perhaps, have demanded attention if the author of it had not founded upon it an argument to set aside the commonly received doctrine that unequalised muscular action is an important source of spinal curvature. A more mischievous error, I believe, could not well be promulgated. It requires us, in considering spinal curvature, to set aside the agents by which action is alone impressed upon the column, and which govern and participate in all its movements, and look upon the latter simply as an elastic, weight-carrying body, liable to be weakened solely by changes within its structures. It is evident that to attempt to solve a mechanical problem without considering all the data entering into it is an absurdity.

The cause of spinal curvature may be summed up as follows:—(1) Destruction of vertebræ by caries or softening; (2) failure of equilibrium between the resistance of the vertebral column and the weight of the body alone, or overweighted with burdens; (3) muscular tractions; (4) frequent repetitions of an attitude in which the spinal column is curved.

The ultimate results of spinal curvature are—(1) absorption of material on the depressed side; (2) retraction of the spinal ligaments and muscles, also on the depressed side; (3)

the formation of a series of two or more curves, antagonising each other in force and direction, and compensatory of the original abnormal deflection, by tending to maintain the head in a perpendicular situation to the feet; and (4) retraction, and subsequent wasting of the muscles, from diminished action, within the concavity of the curves.

Now, it needs no argument to show that when a curve is the result of a disturbed equilibrium, from a too great superincumbent weight, relative or actual, or from imperfectly antagonised muscular action, a primary object should be to remove the superincumbent weight and antagonise the exaggerated muscular action. It is clear also that, in whatever manner this object can be obtained, it will offer the most rational means for obviating the absorption of material arising from improperly distributed pressure and the retraction of ligaments and muscles. The removal of superincumbent weight and the antagonising of exaggerated muscular traction are obviously mechanical questions; hence the treatment of spinal curvature forms in an especial manner a branch of Orthopraxy.

Experience has abundantly taught that medicine is all but powerless in distortions of the spine without mechanical aid. The most ably conducted treatment of the peculiar form of debility which may be at the foundation of the deformity is of no avail, unless the mechanical requirements of the case are first attended to. Physic, change of climate, and, although in a less degree, gymnastics, are alike unavailing to unfold a confirmed curve, or restore the elasticity of an impaired ligament, or lengthen a retracted muscle. But if the pressure be removed from a defective vertebra, and the tendency to retraction of ligaments and muscles be counteracted mechanically, then medicine, change of climate, and gymnastics, by invigorating the debilitated parts, may induce in them a healthier nutrition, and enable them best to resist the tendency to distortion. Orthopraxy, indeed, is not the substitute for, but the helpmate of, the physician and surgeon.

In the further consideration of this subject I shall adopt the following arrangement:

1. THE PRODUCTION OF VERTEBRAL CURVES.
2. LUMBAR CURVATURE.
3. DORSAL CURVATURE.
4. DOUBLE LATERAL CURVATURE.

5. Construction of Spinal Apparatuses.
6. Appliances to act upon the Spine through the medium of Recumbency.
7. Appliances for removing Weight from the Spine.
8. Appliances for affording Lateral Support to the Spine.
9. Deformities of the Pelvis.

Cervical curvature has already been treated in the sections on deformities and debilities of the Head and Neck.

1. *On the Production of Vertebral Curves.*—The spine in its quiescent state, that is to say, when the body is erect and motionless, presents, at its posterior region, a perfectly vertical line, having the head at the superior extremity, and resting inferiorly upon a horizontal base in the transverse axis of the pelvis. When the head and pelvis are in this position, each of the bones, forming the spine has its perpendicular axis in a line corresponding with one drawn from the base of the skull to the sacro-coccygeal articulation, which said line divides the pelvis into two equal parts. Whilst in this condition the weight of the trunk is evenly distributed, and

the forces acting upon the vertebral column are in perfect equilibrium, as may be proved by showing that the angle formed by the spine and ilium on the right side of the body corresponds precisely with the angle existing on the left side (Fig. 63, No. 1). Thus the head, trunk, and upper extremities are found to be in equipoise, and so long as the mechanical powers that sustain this state of things remain undisturbed the whole external form presents an appearance of symmetrical balance. The slightest movement, however, serves to derange the equilibrium; but in the healthy and vigorous frame the disturbance leads to other arrangements calculated to preserve the component regions of the human body in a state of balance, although sometimes at the expense of a true symmetric disposition of relative parts.

When the spine, which forms the general centre in all movements of the trunk, can reassume with facility the perpendicular position first described, after having yielded to whatever accidental disturbance which, for the time, may have led to a deflected position, it is free from "curvature" in the pathological sense of the term; it is, indeed, normal. It follows, therefore, that deformity of the spine only exists when the column is incapable of resuming its vertical position.

Whatever may be the cause which leads to interference with the healthy and natural balance of the spine—whether disease of the vertebræ, or of the interposed cartilages, or disordered muscular action—its result is a departure of one or more bodies of the vertebræ from the true vertical line hitherto held by them ; and as the head thus loses, to a certain degree, the base that sustained it, an addition of its weight is given to the yielding side. Lateral vertebral obliquity ensues, the evil of which is attempted to be obviated by an involuntary muscular effort to restore the head and upper portion of the spine to their original position. If the cause of the deflection were only due to ordinary muscular action, the effort thus made would bring the spine back to its normal straightness ; but, as in the case supposed, there is permanent mischief, the head can only be restored to a point vertical with the plane of the pelvis, by flexing another part of the spine, either above or below the original vertebral arc. This will be more clearly understood from the following diagrams (Fig. 63).

FIG. 63.

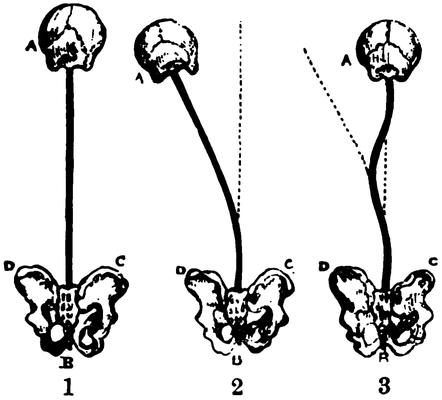


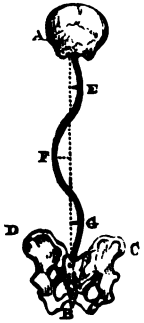
Fig. 1 represents the natural position maintained by the spine, head, and pelvis, A B being the vertical, and C D the horizontal planes.

Fig. 2 shows the primary condition arising from an undue approximation of the bodies of the lumbar vertebræ on their left side.

Fig. 3 exhibits the effort at compensation made by the upper part of the spine, and the formation of a secondary curve.

In these drawings it will be perceived that when the head returns to its primary position, it does not do so, in the first instance, by an entire obliteration of the curve that followed its displacement, but by transferring a small portion of the arc of curvature *beyond* the line of gravity, and setting up another arc of a proportionate magnitude opposite to it, by which the equilibrium is restored, although by the production of two curves instead of one. Should, however, those muscles situated between the dorsal concavity and the pelvis act with increased vigour, while the first deflection (G, Fig. 64) is in the course of formation, it is then perfectly possible that the effort made by the head to return to its normal position, would so favour the exercise of this muscular activity as to induce a disturbance of balance by bringing the head again out of equipose, but on the right instead of on the left side. This, upon the head becoming restored, would lead to the formation of a tertiary or third curve, to ensure equilibrium between the head, spine, and pelvis. The following diagram (Fig. 64) explains the position assumed by the spine after the production of a third arc of curvature, and shows the manner in which equipoise becomes established through the medium of the created curves. First, the spine, it is assumed, yields towards the right side, forming the curve G. To re-establish the equilibrium which has been disturbed by this deflection, the head and upper part of the spine are moved to the left side, thus creating the curve F. In consequence, however, of the muscular traction exercised between the right side of the pelvis and the concave dorsal region, the head is carried too far in this direction, which necessitates the formation of a third curve, E, to bring it into its normal position.*

FIG. 64.



It will moreover be seen that a line at F, drawn at right angles from the apex of the great arc of dorsal curvature on the left side to a true vertical line between head and pelvis, is exactly equal in length to the sum of two lines drawn from E G, the apices of the opposite curves, at right angles to the same vertical straight line, thus showing that the force of gravitation is equally exercised upon both sides of the vertical line drawn from the base of the skull to the centre of the pelvis.

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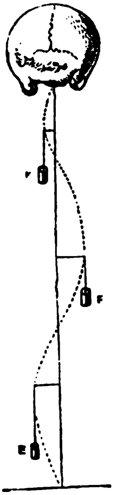
* Although in this illustration the original curve is assumed to be in the lumbar region, the same results may occur when the primary deflection exists in any other part of the spine.

FIG. 65.



To illustrate this statement by a simple mechanical experiment, let an upright semi-elastic rod be supposed to have three transverse arms attached to the parts corresponding with the centres of spinal curvature. If a weight of 10 lbs. were suspended at E, the whole rod would yield, and ultimately fall to the left side; but if 12 lbs. were placed at F, then the rod would yield to the right side, and the only means by which it could be kept in equilibrium would be to place 2 lbs. at K.

The aptitude of the spine, when abnormally deflected, to assume a series of curves, depends upon the elasticity of its formation. Consisting of several separate bodies, each having a distinct centre of motion, and these being influenced by the elastic substance (intervertebral cartilage) placed between them, it follows that the slightest horizontal deviation in any one component part leads to a disturbance of stability in the whole column, and produces the effects described.

Upon a clear understanding of the manner in which vertebral curves are formed depends the correctness of the treatment by which their reduction can be undertaken.

It is well known that a considerable amount of weight can be borne on the apex of a perpendicular column without inducing lateral deviation; but should any cause arise tending to displace the base upon which the column rests, or diminish resistance in any part of its structure, disturbance of equilibrium immediately arises, and the weight no longer rests in equipoise over the base of support, but inclines in the direction of least resistance.

If the weight were left to itself, it would speedily fall; but if the column be composed of elastic material, and possesses sufficient flexibility to yield in any direction, then the displaced weight may be restored to equilibrium by the formation of a curve or curves so arranged as to bring the weight back over the line of gravity. For it would be impossible to rearrange the equipoise of the column, except by resorting to compensating arcs of deflection. For instance, let it be supposed that a weight of ten pounds rests upon the extremity of an elastic column twenty inches high, and that, in consequence of some structural defect at a distance of five inches from its base, the weight causes it to yield in a curved form to the right side. It is obvious that the only means by which the displaced weight can be restored to its first position, without unfolding the primary curve, is by producing a deflection in the column to the left side at five inches from the top, and bringing thus the whole structure into such a position as to make a vertical line from the centre of the column (at ten inches from either end) fall within the base. This establishes equilibrium, and offers a rough example of that which takes place in the formation of spinal curvature.

In the illustrations given the formation of the secondary curves is impressed from without. Apart from this external agency, the primary deflection would increase without interruption. An inorganic, elastic column does not possess any self-generated compensating power. In the living subject, however, such a power exists and is exercised unconsciously, and the great agents of its action are the muscles. The compensatory curves are the results of the automatic efforts to rectify the evils arising from the primary deflection, and their formation is conclusive evidence against the theory of a "vigilant repose" being the normal condition of the spinal muscles when not voluntarily exercised.

The great doctrine to be learned from this brief exposition of the genesis of spinal curves is this, namely, *the impossibility of one arc of curvature ever existing without a secondary curve of compensation being established.* Too much importance can scarcely be attached to this proposition. It is the solid basis of all sound methods for the successful treatment of spinal curvature. Its neglect has been the great source of failure in treatment.

2. *Lumbar Curvature.*—Whether spinal curvature shows itself primarily in the dorsal or lumbar regions is a much controverted point. Mr. Skey believed that lumbar curvature is the earliest formed. He argued that Nature has given the loins greater freedom of motion by placing that part of the body midway between the head and feet, so that the divergent lines of obliquity formed by those portions of the body meet in the lumbar region. From this he inferred that, in the majority of cases, the primary seat of curvature is the loins.* Dr. Little thinks that the part of the column principally affected is the dorsal region; and in the greatest number of cases the vertebræ, he believes, incline towards the right side.† Dr. Bühring, who holds the same opinion, asserts that this peculiarity is due to a thoracic curve which

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* 'Practical Essay on Lateral Curvature of the Spine,' pp. 4—6.

† Little, 'On Deformities,' p. 365.

always exists on that side, in consequence of the spinal column being unequally loaded by the heart and great blood-vessels on the one side and the liver on the other. Mr. Hare considers that the earliest sign of deformity is a slight curvature of the vertebræ in the inter-scapular region.* Beclard says that this occurs because the right arm is most used. Mr. Lonsdale has declared that, when a *second* deflection exists, it occupies the lumbar region, thus showing his belief in the primary existence of dorsal deflection. From these expressions of opinion it would be concluded that spinal curvature rarely occurs in the lumbar region dissociated from dorsal deflection. In what proportion of cases the former is found apart from the latter cannot be stated. Practically, however, it is sufficient to know that lumbar curvature is comparatively a rare affection, but that occasionally the orthopractic mechanician is called upon to treat it.

Lumbar curvature may exist in three distinct directions, viz., lateral, posterior, and anterior.

The salient features of *lateral lumbar curvature* are an unequal prominence of the bony and muscular structure forming the loins, with an approximation between the hip and lower margin of the ribs on the side opposite to that of the distortion. This form of curvature is almost invariably accompanied by obliquity of the pelvis, leading to shortening of the leg as a compensation for disturbance of vertebral equilibrium. Owing to the amount of pelvic displacement generally caused by this affection, the shoulders of the patient do not deviate so much from their natural horizontal position. The following diagram (Fig. 66) explains the conditions presented by the deformity. It will be seen, from this drawing, that the left hip is raised, the corresponding leg being shortened, and that the right side of the lumbar vertebræ is unduly prominent. The same condition of deformity may exist on the opposite side, when the lumbar arc is reversed.

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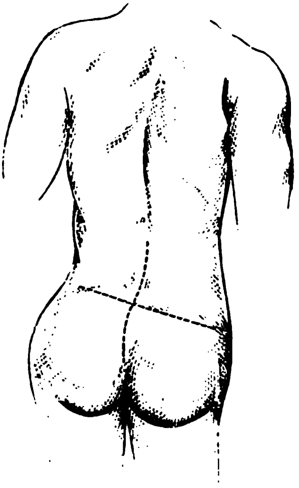
* Hare, 'On Spinal Disease,' p. 64.

To remedy this deformity it is necessary to restore the level of the pelvis, whilst overcoming, at the same time, the vertebral curvature. The simplest apparatus for effecting these objects is constructed as follows (Fig. 67):—Two lateral stems support the arms, whilst the hips are encircled by a narrow padded belt formed of light metal. On the highest point of the vertebral

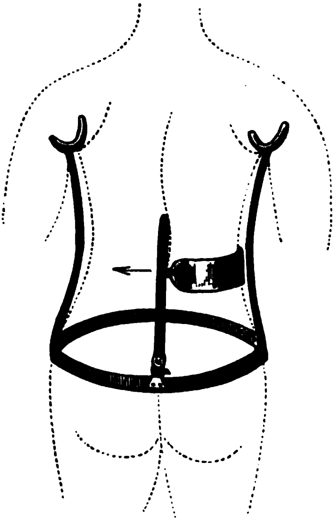
FIG. 66.



deformity a padded plate rests, which is fixed to a posterior lever having a ratchet motion at the sacral part of the pelvic band.

To bring this lever into action the ratchet-screw must be turned from right to left, which produces a movement of the lumbar plate or pad in the same direction. This creates a force which reacts against the left hip and axilla, and tends to diminish the lumbar curve and depress the uplifted pelvis.

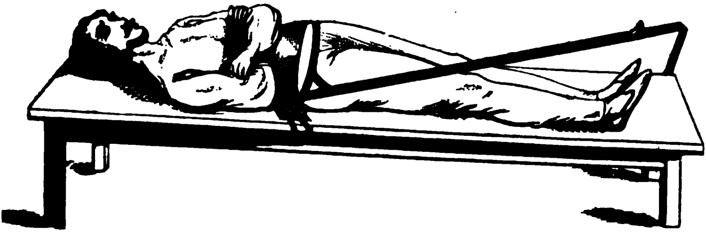
Fig. 67.



An apparatus of this form possesses the advantage of being portable and easily concealed by the dress; and it has consequently been largely adopted by English surgeons.

In conjunction with this apparatus the following plan of extension may be adopted :—The patient is placed in a recumbent posture on an inclined plane or couch, fixed at an angle of twenty-five degrees. The chin is secured by a silken strap; next there is placed around the pelvis a padded band, with a long leathern strap ending in a ratchet-wheel fixed obliquely at the base of the inclined plane, in a direction opposite to the uplifted hip. Another belt, formed of soft material, passes round the lumbar arc of curvature, and is fixed to the opposite margin of the plane. The arms are supported by padded crutches, also fixed to the plane, which thus secures the horizontal position of the shoulders, and affords a fixed point for the pelvis to react against when extension of the lumbar curve commences. This form of appliance was invented by the author, and has been found of the greatest value when used at night, after the apparatus previously described has been withdrawn. It can also be adopted both by night and by day, where severe lumbar curvature has to be conquered. By tightening the strap attached to the ratchet-wheel, the pelvis is drawn downwards, and, the arms being

FIG. 68.



sustained by the crutches, and the head firmly held by the chin-strap, an expansion of the lumbar curve is obtained, retrogression being prevented by firmly securing the lumbar belt (which passes across the curvature) to the side of the inclined plane.

Another variety of lumbar distortion is an abnormal arching forwards of the loins (*anterior lumbar curvature*). This kind of curvature frequently coexists with a bend of the whole course of the spine, the column forming a long arch with a deep hollow in the loins. The technical name by which this variety of distortion is known is "lordosis."* Traction of the longissimus dorsi and sacro-lumbalis muscles, or a wasting of the lumbar intervertebral cartilages on their posterior surfaces, are the principal causes of this condition. Each may exist apart from the other, or both may be found combined: the latter being the most common occurrence. Patients who suffer from this form of spinal distortion find it extremely difficult to walk or stand without throwing the abdomen forward in an unnatural and inelegant manner. The shoulders are generally rounded. When this deformity has existed for any length of time it is irremediable. For its early stages various mechanical appliances are constructed. The simplest apparatus consists of a pelvic band, with two lateral uprights (Fig. 69). Across the abdomen a deep webbing band is placed, the extremities being reflected over the side uprights, and brought again to the front, where they are secured by lacing. The action of this instrument tends to depress the anterior surface of the curve, and so gradually lessen the vertebral deformity.

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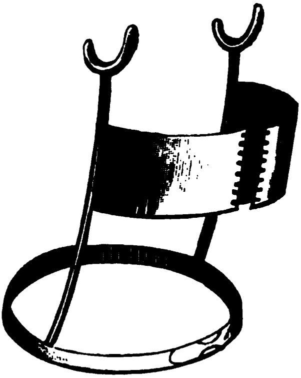
* λορδὸς, 'curved,' 'bent;' a name given to curvatures of the bones in general, and particularly to anterior curvatures of the vertebral column.

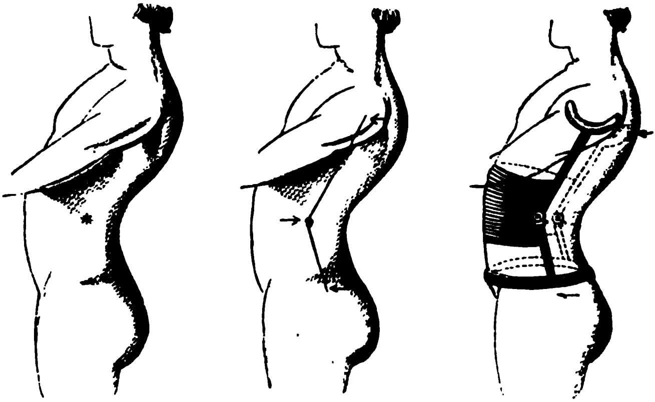
FIG. 69.



Another form of instrument is based upon the supposition that a mechanical centre exists, around which the curvature of the spine arranges itself. This is to be sought for about the centre of the concavity; but as the point required cannot be immediately reached, it becomes necessary to construct the mechanism in such a manner as to let its axis agree with a line drawn transversely across the thorax from the centre of the curve to the sides of the body. Thus the apparatus acts around the fixed point referred to in question. In the accompanying diagrams (Fig. 70) this is explained.

The first drawing represents a lateral view of the body affected by lumbar lordosis, and the asterisk indicates the point where the

FIG. 70.

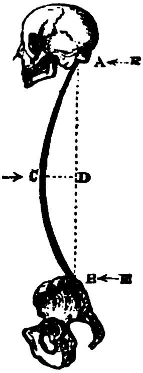


axis of the curve is to be found. The second drawing depicts an instrument so arranged that its artificial axes correspond exactly with the centre of curvature.

This apparatus is formed by a pelvic band and two lateral uprights, and at the axial point, marked in the first drawing by an asterisk, a rack-and-pinion motion is placed. A deep webbing strap passes across the abdomen, and the arms are supported by padded crutch-heads fixed to the uprights. Upon moving the rack and pinion centres with a key, fitted to the mechanism, pressure against three points occurs: first, on the abdomen, by means of the webbing band; next, on the sacrum, through the medium of the pelvic belt; and thirdly, on the armpits, owing to the resistance of the crutches. The object sought is the expansion of the curvature by pressure upon the arc and extension of its extremities. In the case under consideration, the abdomen forms the crown of the arc; the posterior surface of the pelvis, one extremity, and the anterior surface of the thorax, the other. The action of the instrument may be thus expressed (Fig. 71):

Let A C B represent the vertebral curve, and D be an imaginary straight line; C will be found

Fig. 71.



to form the centre of the curve, having A B as its extremities.

Now, to reduce A C B to a plane parallel with D, a fulcrum must be established at C, and the extremities of the curve be drawn towards it, in the direction E E.

The fulcrum C is formed by the webbing-band. The expanding power, or leverage, is given by the uprights, which constitute two levers of the second order, having their centre at the rack and pinion.

The pelvic band and the arm-rests move in slight circles around the central rack and pinions, and thus gradually bring A C B into the same parallel plane with D.

I may here remark that, in all cases where mechanical deductions are based upon changes sought to be produced in the human body, it must be borne in mind that only an approximate result is ever obtained. Owing to the softness, mobility, and vitality of the tissues against which mechanical force is brought to bear, the actions of instruments cannot be rigidly calculated, as when operating on an insensitive, inorganic body. Still, in constructing an apparatus, it is necessary, in the first instance, to reason as if the different structures forming the human body possessed the same power of resistance as a solid substance. If this were not done it would be impossible to arrive at any conclusions as to the arrangement of appliances intended to redress deformities of the human frame. For instance, I assume that the various spinal curves possess centres, and that within the arc there is a certain point, around which the remaining portions of the spinal column and its adjacent structures group themselves, and that a knowledge of these centres is necessary in the construction of spinal instruments. But the multitude of movements induced in the different elements of the spinal column by the application of force, is so great that these centres can only be approximatively, not absolutely, determined. This, however, is sufficient for all practical purposes.

Another plan occasionally resorted to in anterior lumbar curvature, is to place the patient on a prone-couch, similar to that shown in the following

FIG. 72.

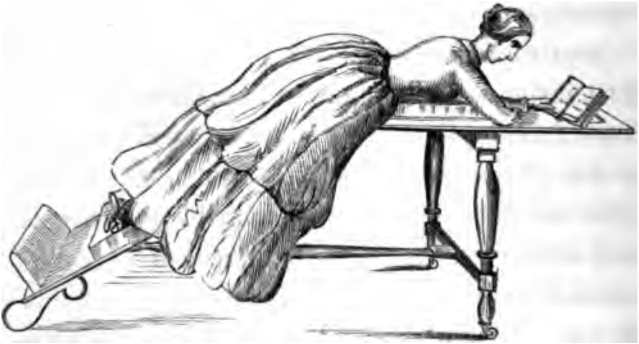


figure (Fig. 72), trusting that the weight of the inferior extremities will gradually redress the curve. It is said that in this method of treatment inspiration, by enlarging the abdomen and extending the longissimi dorsi muscles, gradually leads to an elongation of the fibres of the latter, and so removes one of the most potent impediments to restorative efforts.

It has been suggested, that the patient should assume none but a sitting posture, the notion being that this position might facilitate the reduction of the curvature by inducing an arching backwards of the whole spine. I am persuaded, however, from my own experience, that nothing succeeds better in these cases than the pelvic-band, with double lateral jointed uprights, as previously described.

There is one condition, still requiring mention, under which lumbar curvature is sometimes found, namely, when the bodies of the vertebræ have rotated upon their perpendicular axes. This deformity is known by a considerable prominence in the loins, sometimes, indeed, mistaken for lumbar abscess, but really constituted by the longissimus dorsi and sacro-lumbalis being thrust backwards by the transverse spinous processes of the lumbar vertebræ. This helical, or corkscrew twist, is invariably found associated with dorsal, and frequently with pelvic displacement.

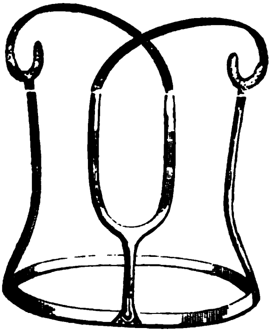
This form of curvature is treated mechanically by the application of an apparatus formed of a pelvic belt and two lateral uprights, together with a posterior stem and a plate resting upon the arc of curvature. But instead of the plate possessing lateral action alone, as in the instrument for lumbar curvature, described previously (Fig. 67), it is furnished with a horizontal rack attached to the plate and moving on a parallel axis. The advantage resulting from this arrangement is, that it produces pressure in an anterior direction by means of the horizontal rack, and in a lateral direction by the ordinary sacral centre. These two motions, judiciously combined, produce a third, as the resultant of both, which acting in the same direction as that in which the spine was originally curved, gradually unfolds the helix and restores the spine to its normal position.

An immense amount of importance was attached, some years since, to the peculiar condition of rotation, observed in the deformity under consideration, and I invented a series of *movements* attached to the plate of an ordinary spinal instrument, by means of which the spine could be acted upon in as many planes as there had previously been directions of distortion. This mechanism, which will be described fully when the treatment of lateral curvature accompanied by axial rotation of the bodies of the vertebræ is discussed, was widely adopted, the adopters, as too frequently happens, rarely acknowledging the source from which they had derived the invention.

Posterior curvature is another of the deformities affecting the lumbar region. It may be due either to disease in the bodies of the vertebræ, or to relaxation of the posterior spinal ligaments. In the former case it is distinguished by a sharp angular prominence, like a knuckle, and is sometimes accompanied by considerable tumefaction on one or both sides of the column. No pressure can be borne upon the arc of curvature or the immediately adjacent region, and, the projection, unless arrested, increases rapidly. This variety of distortion affords a clear illustration of the importance of a surgical appreciation of the pathological condition existing prior to the adoption of any apparatus. If powerful pressure were employed on the arc of curvature, a diseased state of the vertebræ existing, not only would considerable pain be excited, but all the symptoms accompanying the curvature would be greatly exaggerated. If the patient were of a strumous diathesis, as happens in nine cases out of ten, the formation of lumbar abscess might be induced, and incalculable mischief occur. But a correct diagnosis of the case having been made, no difficulty is experienced in adopting mechanical treatment. The instrument devised for these cases consists of a pelvic band, with two lateral sliding uprights, and a bifurcated vertebral stem, governed in its action by a rack-and-pinion centre, acting in an anterior direction. Over the arc of the curve, a soft chamois leather pad is placed, while the arms of the bifurcated stem rest gently against the angles of the ribs, and the heads of the transverse spinal processes. The rack and pinion is simply employed to secure apposition, not pressure.*

Upon the application of this instrument, the

FIG. 73.



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* This instrument has met with the approval of, and been adopted by, Mr. Erichsen, Mr. Fergusson, Mr. Hilton, Mr. Paget, Mr. Tatum, and other leading surgeons.

lumbar vertebræ are held in a perfectly steady and immovable position, whilst the apex only of the curve receives the slight pressure of a soft pad. According to the law established by Mr. Hilton,* all diseased surfaces and structures require for the renewal of their healthy state absolute physical rest. The instrument described is intended to secure this condition in the case of posterior lumbar curvature.

In Germany and Austria, and also in many parts of England, it is usual to place patients who are suffering from diseased lumbar vertebræ in a recumbent posture, under an impression that rest is more easily obtained in this position than any other. Reflection will, however, show that the vertebræ are far more likely to be disturbed by restlessness such as must always be induced by the constant maintenance of a restrained posture, than by the adaptation of an instrument, which while fixing the vertebral column and trunk leaves movement free.

But it is sometimes necessary to conjoin partial recumbency with mechanical support. When this combination of treatment is adopted, the best kind of rest is obtained from the use of an American chair, so constructed as to permit the angle at which the patient reclines being varied.

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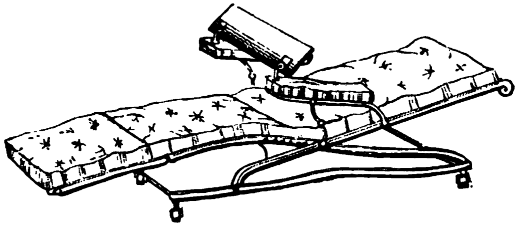
* 'Lectures on Pain and the Therapeutic Influence of Mechanical and Physiological Rest in Accidents and Surgical Diseases.' 8vo, 1864.

It may seem paradoxical to declare that the purely horizontal posture is one of the least actual rest, yet this is the case. The vertebral column, excluding the sacrum, possesses in its natural condition, as already stated, three curves, one including the cervical, another the dorsal, and the third the lumbar region. Now, when the body is placed in a horizontal position, as upon a hard board or the floor, the concavities of the lumbar and cervical curves are not only unsupported, but materially increased by the projection of the back of the head and the buttocks. Thus those muscles and ligaments which lie in the hollow of these arcs are kept in a continual state of tension and irritability. But if, instead of the body being placed perfectly horizontal, it is laid upon an inclined surface, so undulated that the curves exactly fit in with those of the human spine, then rest in its most perfect condition is gained. To secure this great desideratum, I have had a chair constructed* in such a manner, that the padding forms an exact counterpart of the back; and to prevent this from being at all disturbed by wear or weight, a firm wooden support is so placed in the rear of the padding as always to maintain the exact shape originally given to it. Not only can the chair itself be placed at any angle, but it may be, if required, fixed in a horizontal position, without sacrificing the advantage of form just specified. The curves can be modified so that the chair may be adapted to different patients.

This chair is suitable to every condition of spinal disturbance, and in cases of mere muscular debility, tends as much to prevent curvature as

FIG. 74.



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[*] This chair is fabricated and sold by Ward & Co., 6, Leicester Square.

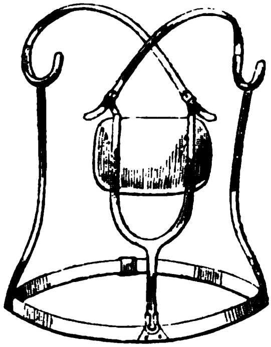
to control the distortion, should it unfortunately arise.

In cases of lumbar curvature originating from disease, the best position of rest is secured when the chair is placed at an angle of 25°.

Posterior curvature of the lumbar vertebræ when arising from debility of the structures presents an arched surface, which is without any tenderness, and has an equal enlargement of muscular substance on either side. The margins of the lower ribs are compressed against the abdomen in front, and the whole body assumes a stooping posture, such as is seen in ordinary relaxation of muscles and ligaments from old age.

The mechanical appliance devised to relieve or remedy this form of curvature consists of a padded pelvic band and two lateral uprights. To the back of the pelvic band, at its sacral surface, a bifurcated lever is attached, acted upon by a rack-and-pinion centre; but instead of the bifurcation supporting both sides of the curve, as in the instrument figured at page 232, it terminates in a padded metal plate, resting upon the curve just *below* the axis of posterior deviation, or, in other words, pressing upon the lower segment of the arc described by the lumbar vertebræ (Fig. 75). The reason for the plate being placed below the

FIG. 75.



vertex or highest point of the curve, instead of directly upon it, is readily understood when the action of the instrument is examined.

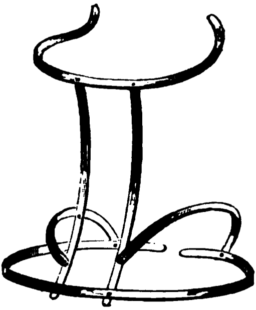
The curve being attributable to a falling forward of the bodies of the lumbar vertebræ, necessitates a corresponding yielding of the upper portion of the thorax, which, although not actually curved in an anatomical sense, adapts itself to the general yielding, in order to maintain the head in equilibrium with the remaining parts of the body. On applying the instrument, if the padded plate were placed where nine persons out of ten would probably adjust it, namely, on the arc of the curve, it would tend to aggravate the distortion by throwing the body more forward; but if placed, as I suggest, immediately below the axis of curvature, the reaction of the arm-piece of the instrument against the thorax of the patient tends to unfold the curve.

In these cases, as a rule, it is hardly possible to make too much pressure against the spine, the only limit being the chance of injuring the tissues lying over the prominent spinous processes. The plate is, however, hollowed so that this danger is diminished and good results from the force exercised against the transverse processes of the vertebræ and the angles of the ribs.

Cases, however, sometimes occur in which pressure cannot be borne. It is then customary to use an instrument of the following form, (Fig. 76) which leaves the spine entirely free in its whole course.

This instrument has the universal pelvic band, but instead of the usual concomitants, "lateral uprights," two vertical stems, shaped to the external contour of the spine, rest against the angles of the ribs, and are surmounted by a padded bar carrying horizontal sliding arm-rests. The instrument is also prevented from falling downwards by hip-bands passing over the crest of each ilium.

FIG. 76.



By establishing extension between the arms and pelvis, in combination with a certain amount of rest afforded to the spine by the vertical stems, the whole column is kept in a state of inaction, which, in cases of spinal irritability, is the main point to be looked to. In infantile cases, the plan adopted is that of carefully moulding a gutta-percha splint to the whole posterior surface of the thorax. This constitutes a kind of trough, which may be so attached to the little patient's body as to prevent any chance of injury to the spine, by an accidental fall or movement.

The appliances described are but a few out of the many which are employed in the treatment of lumbar curvature. All, however, are constructed upon the same principles, and it would be profitless to enter into a more detailed account of the different modifications.

3. *Dorsal Curvature.*—Dorsal curvature may be divided into three varieties, which derive their names from the resulting deformity: viz., posterior or cyphosis,* anterior or lordosis, and lateral or scoliosis.†

When the spine yields in an outward direction it is called cyphosis, and presents an arching backwards of the whole dorsal region. This name strictly applies to the deformity when it is uncomplicated by the presence of caries or osseous disease, and arises simply from a relaxed condition of those ligaments and muscles whose function it is to hold the column erect.

It need hardly be stated that when these tissues are unduly lax, a leaning forward of the spine ensues, with anterior compression of the intervertebral cartilages, the effect of which is to disturb the equilibrium of the column, and lead to the formation of a posterior curve. The earliest sign of this deformity is a constant sense of aching or weariness in the loins, accompanied by inability to sit perfectly erect for any length of time without pain being excited. Finding that any attempt to hold the spine in an erect position creates discomfort, the patient is almost involuntarily led to use soft cushions and hollow-backed easy chairs as the most agreeable means for obtaining rest. This, however, unfortunately only serves to increase the deformity still further, by an approximation of the superior and inferior extremities of the curve, and an extension of the posterior spinous ligaments. When the spine has reached this state it happens that when the patient is in the act of standing or walking, the weight of the head and upper extremities carry them in a forward direction, much beyond the gravital line as established normally between the base of the skull and the pelvis; and it is to restore their equilibrium that a posterior curve is created. The mechanical treatment of this deformity requires great judgment, otherwise the distortion may be exaggerated.

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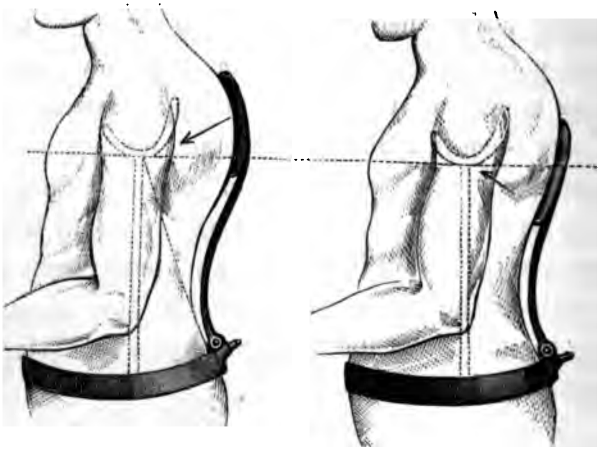
* κυφος, gibbous.

† σκολιος, crooked.

When the body arches forwards in the manner described, the anterior portion of the intervertebral cartilages is compressed, and each vertebra above the axis of curvature is placed in an oblique position, with an antero-inferior direction. Should pressure of any kind be made, either upon or above the centre of the curve, the deformity would be increased. For if the force so applied rested against the highest point of the curve, it would tend to throw the whole body forward, whilst if it were applied above this point, then a compression of the curve upon itself, in a downward direction, would ensue. In both cases the patient must be harmed. But if, instead of making the

FIG. 77.



mechanical resistance act against either the centre —which is too commonly done—or the higher segment—which frequently happens—the support is placed at least two vertebræ beneath the axis of distortion, then expansion of the extremities of the curve may be secured, and consequent depression of its arc. To explain this more clearly the annexed diagrams (Fig. 77) are given.

In the first figure is shown the action of an instrument with a vertebral pad resting on the axis of the curve. The form of the spinal instrument here supposed to be adopted, is that ordinarily used in such cases, consisting of a padded pelvic band with two lateral arm-rests and a vertebral plate. This plate is governed in its action by a ratchet centre fixed at the back of the pelvic band. By this means pressure can be used upon the curve. The force applied reacts from the arm-rests, which should be rigidly attached to the sides of the pelvic band. In the diagram the dotted line that passes from the pelvic centre of movement will be found to be a radius of a circle, a segment of which is traversed by the pad of the instrument when it is set in motion. By studying the direction taken by the periphery of this circle, it will be apparent that the spine, if it yields at all, must do so in an anterior and downward direction. This would increase the distortion.

In the second figure the pad of the instrument rests beneath the axis of curvature, and the direction of force being estimated as in the second figure, it will be seen that the curve must of necessity expand upon pressure being made on its lower segment. In this case the reaction of the axillary supports aids expansion: in the former case, it limits to some extent the ill-effects arising from an erroneous application of force.

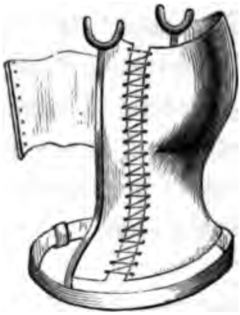
The practical rule in all cases of posterior dorsal curvature, *unaccompanied by osseous disease*, is carefully to place the pad beneath the centre of the distortion, the arm-crutches being sufficiently high and oblique to act backwards against the axillæ; the instrument being also secured from slipping downwards by a well-fitting pelvic adjustment. Under these conditions, the pressure of the pad being slowly increased by means of the ratchet centre, a gradual expansion of the curve may be obtained.

Posterior curvature frequently arises from destructive disease of the bony substance of the vertebræ (Pott's disease). This is generally distinguished from ordinary cyphosis by one or more of the spinous processes becoming sharply prominent and presenting the appearance of a knuckle; hence this deformity is sometimes called angular curvature. When hardly pressed, pain is occasioned, either at the angle itself or in the immediate neighbourhood. Thus the mechanical conditions presented by this variety of spinal distortion differ considerably from those of the deformity last treated of, as any attempt to make the same amount of pressure below the axis of curvature would lead to most disastrous results.

The spinal instruments adopted for angular curvature are few in number. Those for distortion unaccompanied by disease of the vertebræ will be first described.

In cases where the distortion exists in young children, or is but of slight extent in adults, the simplest form of support consists of a leathern shield, carefully moulded to the back, and furnished with lateral supports beneath the arms; without which any attempt to support the spine is useless. A soft band passes across the front of the chest and prevents the body from slipping out of the apparatus. This shield should be so constructed as to support the curvature beneath its apex, whilst the surface above it remains free. Its form and the manner in which it should be applied are figured in the following drawing (Fig. 78).

Fig. 78.



When the distortion has become strongly marked, and much deviation from the perpendicular has resulted, the best form of appliance will be found to be a padded pelvic band, with two sliding lateral supports, having a laced band passing over the front of the sternum. At the posterior centre of the pelvic band a vertebral stem, accurately curved to the shape of the back, should be fixed, with a padded plate, corresponding in form to the lower segment of the curve attached to it. At the base of the vertebral stem a rack-and-pinion centre is placed, for the purpose of regulating the pressure produced by the plate upon the spine. The mechanical action of this instrument is threefold. First, it takes off all weight from the spine, by means of the lateral crutches. Next, it secures rest and affords support to the yielding vertebræ. And thirdly, it diminishes the deformity by expanding the extremities of the curve and depressing its centre. These effects result from the pressure made by the plate upon the lower half of the curve, and the reaction established at the arm-pieces against its upper portion. This form of instrument is represented in Fig. 77.

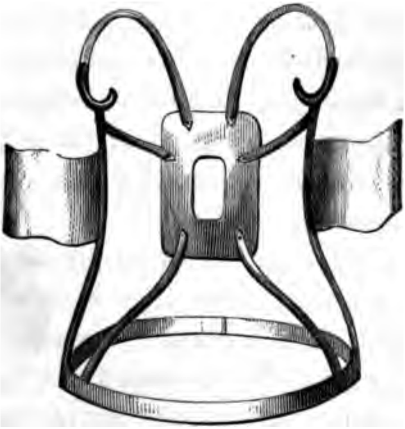
Another kind of support consists of a bifurcated lever, resting against the transverse processes of the vertebræ. This, however, is only adopted in cases where the spinous processes are incapable of bearing pressure. Its mechanical effect is precisely the same as that of the padded plate. A drawing of this form of appliance has already been given at page 232; the only difference being that it is there adjusted for posterior lumbar curvature.

These are the appliances usually adopted for posterior curvature, unassociated with osseous disease; but where caries of the vertebræ exists other forms are usually employed.

Amongst the most noteworthy of these is an instrument formed by two lateral uprights and a pelvic band. To the posterior margins of the lateral supports four buckles are fixed, which give attachment to a carefully prepared soft leather pad, having an aperture in the centre, and so arranged that the lower edge is wedge-shaped; the reason for this being, that the curve should be supported just as by the plate apparatus previously described, but not so rigidly.

Although, apparently, a minor matter, the utmost importance is attached to the manner in which the straps are fixed. They should be so arranged that the two lower straps may form a supporting and oblique surface for the spine to rest against, whilst the two upper ones will sim-

FIG. 79.

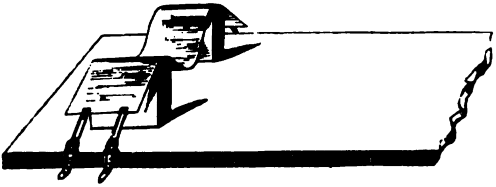


ply keep the pad *in situ*. Without this precaution the treatment might become mischievous, by inducing mechanical pressure in the wrong place, and in a faulty direction.

Occasionally a padded plate of light construction is adopted; but, in the distortion under consideration, its effects are uncertain, and not comparable in value with the hollow pad just described.

A plan which I found pursued very extensively in the neighbourhood of Vienna, is that of placing the patient on a couch so prepared that a webbing band receives the weight of the patient, who reclines with the face downwards. The band is stretched between two fixed lateral rods and passes above the axis of the curve, and across the upper part of the sternum; its action being the reverse of that sought to be obtained by the use of the back pad, or plate. The disadvantage attached to this mode of treatment

FIG. 80.



is, that of keeping the patient constantly confined to one position. The plan has, however, very strenuous advocates on the Continent.

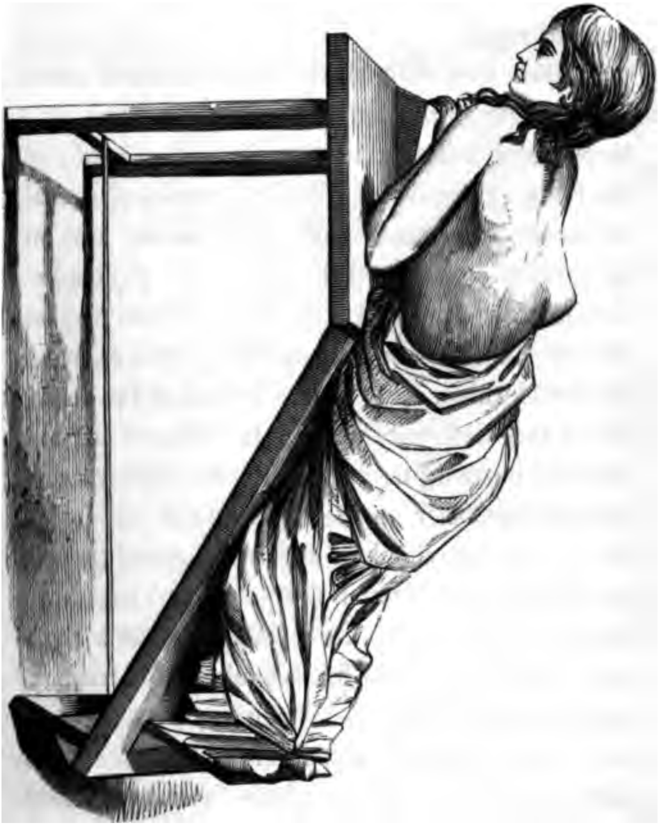
It has been the custom in London to place patients affected with angular curvature in a prone position; for which purpose several highly ingenious couches have been invented. The one best known, and most used, is that called "Verralls" (Fig. 81).

The mechanical aim sought to be achieved by this arrangement, is that of removing the superincumbent weight of the head and shoulders from the spine, whilst the lower extremities and pelvis, being placed on an inclined plane, tend by their mere weight to slightly expand the curvature, without irritating the diseased vertebræ.

In the majority of "orthopædic," "orthorachitic," "prone," and other couches, the governing idea is that of imparting perfect rest to the diseased vertebræ. It is, however, an indisputable fact, that a portable apparatus, when carefully adjusted, gives much more actual rest to the spine than any couch, and with this signal advantage, that a patient's health does not suffer injury from a protracted state of forced inactivity.

The next form of distortion presented by the

Fig. 81.



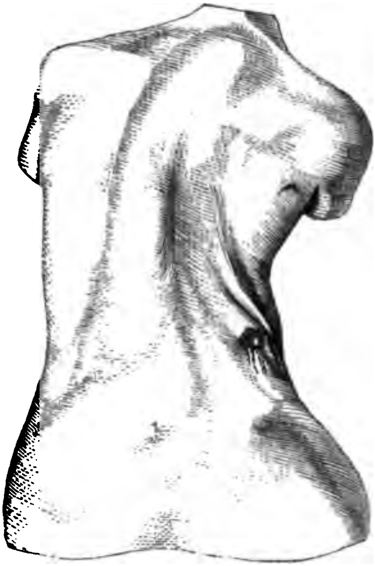
dorsal vertebræ is termed "*lateral,*" from the vertebral column being arched sideways.

It is certain, however, that a simple lateral dorsal curve hardly ever exists; it is either combined with deflection of the lumbar, or of the cervical region.

I have only seen three clearly marked cases of a single dorsal curve, and these were due to partial exfoliation of the ribs on one side of the body. The distinguishing features of dorsal curvature, in these exceptional cases, are an approximation between the armpit and hip on one side of the body, with a projection of the ribs on the other, accompanied by uplifting of the scapular or shoulderblade (Fig. 82). In one of the cases, where this deformity existed in its most marked degree, the margins of the ribs completely overlapped each other on the right side of the body, whilst the left shoulder and side formed an arc, having its extremities in the pelvis and neck, and its centre in the bodies of the fifth and sixth dorsal vertebræ. The left scapula had become so much displaced that its inferior angle was almost on a level with the axilla on that side. It is needless to say that the whole thorax exhibited a very contorted appearance.

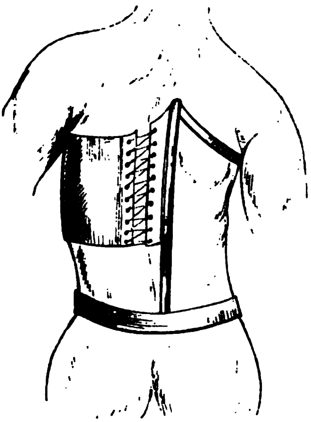
Two forms of apparatus have been specially devised for the relief of this deformity. The first consists of a padded pelvic band surrounding the

FIG. 82.



hips, with two perpendicular levers springing from it, one in front of the thorax, the other behind it. A webbing band, passing over the projecting side of the chest, connects the back and front levers together. A padded band, attached to the upper extremities of the levers, passes beneath the armpit of the opposite side (Fig. 83). By this apparatus steady pressure can be exercised on the convexity of the curvature,

FIG. 83.



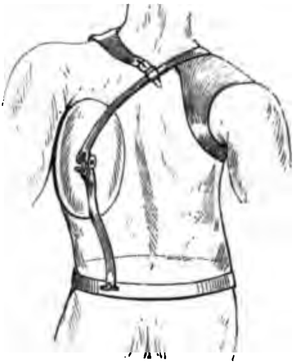
the depressed shoulder being at the same time elevated by the action of the axillary band.

Another kind of instrument applicable to these cases is constructed as follows:

A padded belt encircles the pelvis. From this belt, on the side where the ribs project, and a little posteriorly, springs a metallic-jointed stem extending from the pelvis to the depressed shoulder (Fig. 84). The pelvic arm of the stem is erect and curved, so as to adapt it to the trunk. To the upper extremity of this arm an oval padded plate is attached, which rests upon the projecting ribs. From the point of junction of the pelvic arm of the stem with this plate, the upper arm springs, and passes obliquely across the back of the thorax to the depressed shoulder, to which the free extremity is attached by means of a broad shoulder and axillary band. The two arms of the stem are joined together by a rack-and-pinion movement. By means of this movement the plate is governed, and graduated pressure can be exercised upon the projecting side of the chest, and consequently on the convexity of the vertebral curve; while, at the same time, the lower segment of the upper arm of the stem being depressed, the depressed shoulder is raised.

The same effect is produced, indeed, by this apparatus, upon the spine as occurs when a bent

FIG. 84.



stick is straightened by placing its convexity against the knee, and pulling at its two extremities with the hands.

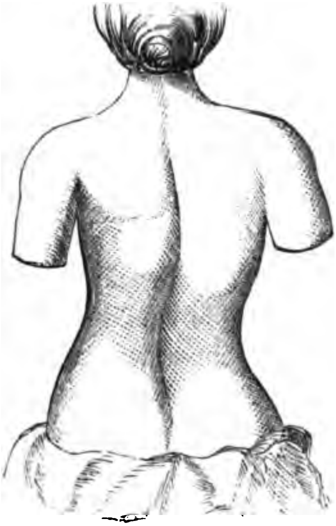
In lateral curvature much disturbance to the health arises from the compression which the contracted ribs exercise upon the lungs, and it is a matter of the highest importance to resort as early as possible to mechanical aid.

Although a single curve rarely exists, yet many appliances intended for the treatment of lateral curvature have evidently been constructed under the fallacious notion that but one arc of deflection has commonly to be dealt with. Amongst those particularly framed on this supposition, may be mentioned the lever belts of Hosard and Tavernier, the spinal apparatus of Lonsdale, and the single plate instrument so frequently adopted. In these inventions the secondary deflections usually observed in lateral curvature have been overlooked. It thus happens that in the appliances just mentioned, the power applied for redressing the distortion chiefly expends itself in exaggerating the compensatory curves.

This subject will, however, be treated at some length when double lateral curvature and its mechanical treatment are considered. Here it will suffice to say, that whenever a double curvature of the spine exists, and pressure is made only on the arc of one curve, increase of the secondary distortion must inevitably follow.

4. *Double Lateral Curvature.*—Double lateral curvature consists of a twofold deflexion of the spinal column in opposite directions. The two arcs of deflection, or curvature, most frequently affect the lumbar and dorsal regions (Fig. 85).

FIG. 85.



It will hereafter be shown that there may be three or even four curves in lateral curvature. The distortion, therefore, would have been more correctly termed "compound lateral curvature." Where only two deflections exist, they are familiarly known as the dorsal and lumbar curves.

The dorsal curve shows itself as an arching sideways of the spine, so that the scapula of one side is tilted out of the position which it naturally occupies on a level with that of the opposite side. This displacement is accompanied by a bulging backwards and outwards of the ribs, on the side of the body which corresponds with the highest point of the dorsal curve. The concavity formed by the distortion is generally accompanied by flattening of the ribs, and ultimately atrophy of the spinal muscles of the same side. For the spine forms a central column between two antagonistic groups of muscles. When a disturbance of equilibrium takes place, and an abnormal curvature is produced, the muscles on the concavity of the curve, whether primarily paralysed, or relatively or absolutely weakened or rendered inactive in comparison with their antagonists, waste away. The opposing muscles, therefore, act uncontrolled in maintaining or exaggerating the curvature, until their contraction is limited by mechanical agency.

The lumbar curve is distinguished by a yielding of the vertebræ in a direction antagonistic to that of the dorsal—thus, if the former arches to the right side of the body, the latter would do so to the left, and *vice versâ.* This curve leads to a considerable amount of projection of the loins, which is due to the sacro-lumbalis and longissimus dorsi muscles becoming displaced, and forming an eminence.

Besides these results, the hip of the side which is opposite to the upper (dorsal) curve projects largely, the ilium being thrust upwards, and the pelvis becoming oblique, in consequence of the changed position of the lumbar and sacral vertebræ.

From whatever cause the equilibrium of the spinal column may have been first disturbed and a lateral deviation induced—whether from inability to support the superincumbent weight of the head and shoulders, arising out of a general debility or a morbid condition of the vertebral tissues, or from muscular traction occasioned by unilateral paralysis or weakening, or, on the other hand, abnormal action of the spinal muscles—the vertebral column, as shown in a previous chapter, in the instinctive efforts to maintain the head and shoulders in equilibrium, assumes a series of two, three, or even four, compensating curves, *never one only*, except under the rare condition discussed in the last section, namely, extensive exfoliation of the ribs of one side. At least I am not aware of a single curve having been observed except under this condition.

The recognition of this truth is so essential to the successful mechanical treatment of double lateral curvature, that I may be pardoned recapitulating briefly the principles which have already been laid down in the section on the production of vertebral curves.

The head represents one extremity of an elastic column, and the pelvis, or hips, the other; the central portion, or spine proper, being capable of movement freely in any given direction, with different degrees, however, of mechanical freedom or intensity at different points.

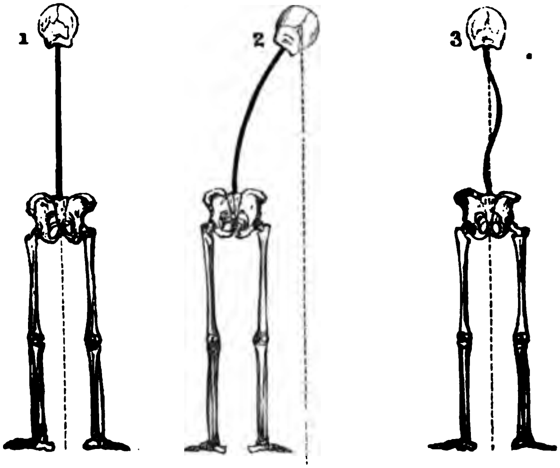
If a deflection of any part of the spinal column should take place by means of which the head would be thrown outside the true line of gravity of the body in an erect position, an instinctive effort is made to restore the normal equilibrium.

In a healthy state of the spine this is brought about by the conjoined action of the spinal muscles and the elasticity of the vertebral column. If, however, the original cause of deflection should have been some morbid condition by which the elasticity of the column at a given point has been damaged, the damage disturbing the normal planes of some of the vertebræ ; or, if the cause be persistent abnormal muscular traction, then the attempt to bring the head within the line of gravity and restore the equilibrium of the trunk is not accompanied by an obliteration of the primary deflection. Under this condition the effort for the restoration of equilibrium results in the formation of another deflection equal in extent to the primary one, but in an opposite direction (Fig. 86, 3). Equilibrium, in fact, can only be restored by the formation of one or more curves compensating for and neutralising the disturbance of gravity caused by the primary curve.

The following diagrams (Fig. 86) show the position assumed by the head in its relation to the pelvis when a single compensating curve exists.

The first diagram represents the head supported by the spine in a vertical position, and the line of gravity is indicated by a dotted mark passing from the top of the skull to a point between the feet.

Fig. 86.

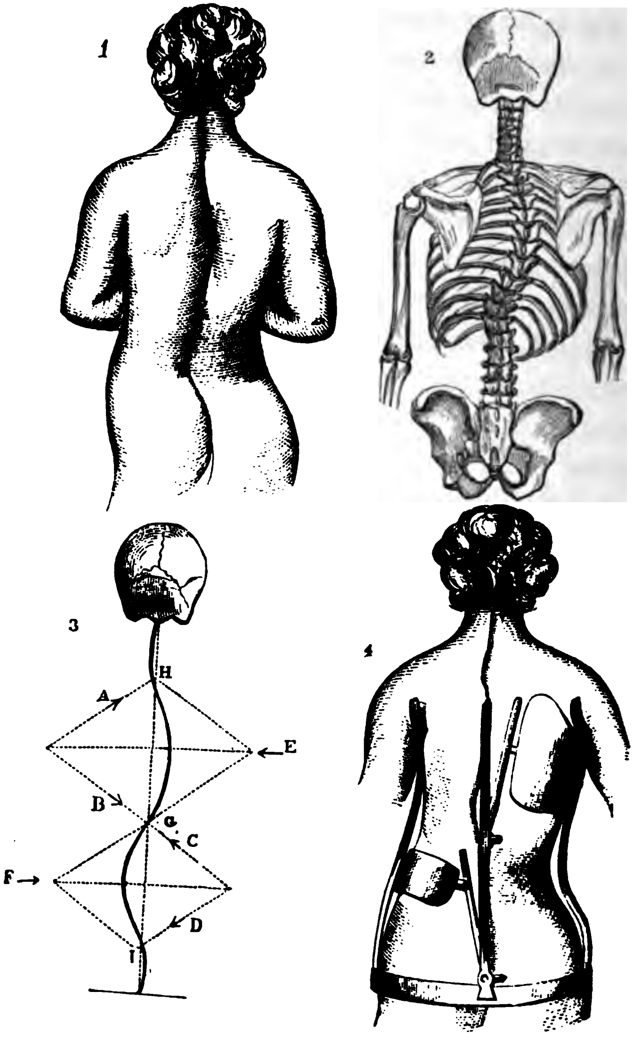


The second diagram exhibits the head deflected to one side, so as to throw the line of gravity beyond its base, as furnished by the feet: in which case the erect position could not be maintained; as, whenever the weight or gravital force of a body is transferred beyond the area of its base, such body can no longer retain a position of equilibrium or rest, but must yield in that direction to which the line of gravity subtends.

The third figure shows the position assumed by the spine on the restoration of equilibrium, the primary deflection being persistent. Equilibrium is not regained by the whole spine returning to its original position, but by the production of a second curve, by means of which the gravital centres of both arcs of curvature are brought within the base formed by the feet, and the head once more resumes its original position—two opposing arcs of spinal curvature having been formed, which counterpoise the head, when taking any other position than that of the central and vertical line of the body.

5. *The principles which should govern the application of Mechanical Apparatuses to Double Lateral Curvature; with a description of a new form of spinal instrument for securing amelioration and eventual cure.*—In my original work on 'Deformities' I described a new form of instrument for the treatment of double lateral curvature. I have recently effected several important improvements upon the original design, by means of which the principles which I seek to teach are more efficiently carried out. Some account of the instrument as first constructed will properly precede a description of its later modification, and

Fig. 87.



facilitate the exposition of the ends sought to be obtained by the mechanism.

In the accompanying plate (Fig. 87) four drawings are given, illustrative of double lateral curvature.

In the first drawing is depicted the dorsal aspect of a patient suffering from double lateral curvature. It will be perceived that the spine presents two distinct curves, the arc of the upper or dorsal deflection passing to the right side, whilst the arc of the lower or lumbar bulges the left. This is the condition most commonly observed in lateral curvature. The same state is assumed to exist in the three following drawings, to give me an opportunity of proving the correctness of the principles which I am about to enunciate.

In the second drawing the osseous structure of the vertebræ is shown as it actually exists in double lateral curvature, the bodies of the vertebræ being oblique, and the margins of the ribs unduly approximated.

In the third drawing an attempt is made to show the exact direction in which force should be applied when it is sought to diminish the deformity by mechanical aid.

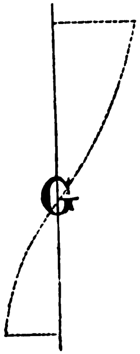
In the fourth drawing is portrayed the instrument I originally designed to secure the application of force in the manner indicated by the preceding diagram.

Let it be remembered that the salient points of the case under consideration are a bending of the upper portion of the spine towards the right side, with a compensating yielding of the spine, at its lowest portion, to the left. When these features present themselves, the right shoulder is found to be lifted up, whilst the left side protrudes. The left arm is also seen to be within the concavity of the dorsal curve, and thus it falls lower than the right.

On consulting the second of the preceding figures it will be seen that the elevation of the right shoulder and depression of the left, with projection of the left side, are necessary consequences of the disturbed axes of the vertebræ, and the formation of the antagonistic curves.

Now, these osseous curves possess two convexities and two concavities, bearing definite ratios to each other, and meeting at a common point, which may be represented by G in the accompanying diagram (Fig. 88). This point corresponds with the termination of the dorsal and the com-

FIG. 88.



mencement of the lumbar curve, and is on the mesial line of the body.

In the third illustration, Fig. 87, both the curves already described are found to possess a common chord, H, G, and I. It is, therefore, apparent that the proper method of compelling these curves to assume a straight line, is the employment of equal but opposite lateral power against the arcs of both. E and F represent the lines of action of the required forces, which, when brought into operation, immediately meet with resistance at H G, and G I, these being the extremities of each curve. For, upon any power being applied at the arc E, resistance must occur at H G, its extremities; but, as resistance at the extremities of an arc may always be resolved into two distinct forces, A B would represent the direction of the ensuing counter-resistance. By the same rule, if power be exercised at F, counter-resistance is to be set up at G I, in the direction C D. Further, the concavity of the other curve, H E G, is embraced by the sides of a parallelogram, A B; whilst the concavity of the arc G, F I, is included in the parallelogram C D. E and F form the diagonals of both these parallelograms, and therefore represent the direction of the forces requisite for the due unfolding of both curves.

But it will also be perceived that the line B, forming the lower side of the parallelogram, A, B, H, G, and the line C, forming the upper side of the parallelogram, C, D, F, G, are coincident—the direction of their forces being equal and opposite—and that they thus negative each other and make their common centre G a fixed point, which fixed point is also the spot at which both the dorsal and lumbar curves join. G is found to be on the mesial line of the body, and vertical to the other fixed point I, as is indicated by the dotted line H, G, I, uniting the base of the skull with the centre of the pelvis.

For practical purposes it may therefore be concluded that to reduce a case of double lateral curvature of the spine, force should be applied to the apices of the arcs in the direction indicated by the lines E, F, and that this force must originate from the two centres G and I.

It follows, then, that any instrument devised for this object should have two centres of movement agreeing with the points G and I of the diagram, and two surfaces of resistance corresponding with E F.

The instrument I originally devised to carry out the end sought is depicted in the fourth drawing (Fig. 87). This instrument possesses two ratchet-centres of movement coinciding with the common centre of the two curves G, and the pelvic centre I. There are also two padded metal plates resting upon the apices of the dorsal and the lumbar arcs of deflection, their force being exercised in directions coincident with the lines E and F. A provision is also made for elongating the extremities of each curve, and uplifting the depressed shoulder by means of lateral crutches fixed to a firm but well-padded pelvic band.

Representing the natural position of the spine, there is also a vertebral metallic rod which affords attachment to the ratchet stems governing the action of the two plates. The whole is held firmly in position by a padded pelvic band, to which both the lateral crutches and the back stem are attached.

I proceed now, aided by the following diagram (Fig. 89), to describe the instrument as I have recently modified it.

The pelvic band with lateral uprights and axillary supports, are constructed as already stated, but the arrangement of the back levers differs. These spring directly from the pelvic band at an angle which has a definite relation to the magnitude of the lumbar and dorsal curves. Thus placed, their action is not unlike that of the human arm, the padded plates which they carry, and which, when the instrument is in position, rest upon the convexities of the two curves, representing the hands.

This similitude is less imaginative than might at first be supposed. Whenever a case of double lateral curvature is presented for examination, the first impulse is sure to lead to pressure being applied against each arc of curvature by the hands of the surgeon. Following this natural indication, it will be seen that compression of each

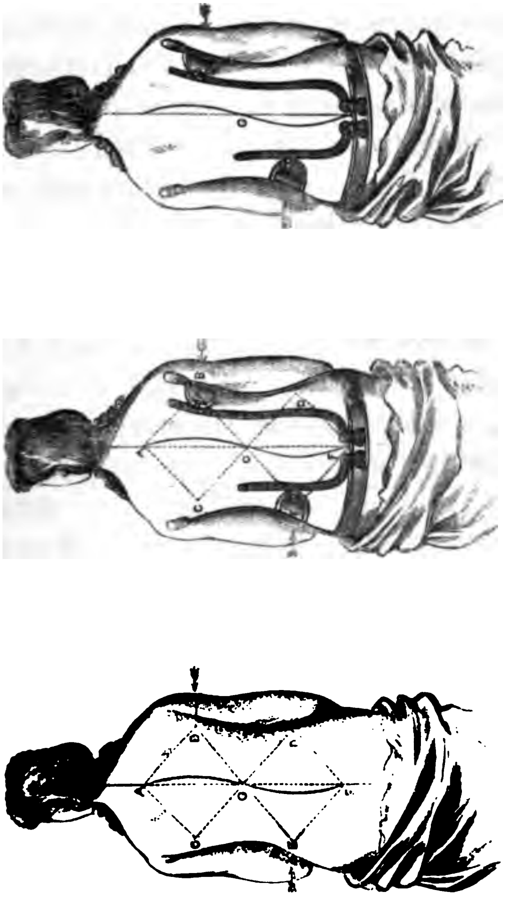


FIG. 89.

vertebral arc acts against the common point of the spine described in the diagram, and that the correct means of reducing spinal curvature are thereby indicated. The two vertebral levers and plates of the spinal instrument really fulfil the function of the human hands and arms. Owing to the angle given to these levers, they tend to elongate the extremities of each spinal arc simultaneously with the exercise of lateral pressure. Although no ratchet-centre is placed at the junction of the vertebral curves, yet by the fact of the forces B E being met by A G, G F, the central part, G, always remains stationary in its relation to the two antagonistic forces employed to act upon the dorsal and lumbar curves; for as the point of junction is in a direct line with the occiput and sacrum, it necessarily follows that the spine, during the time the curves are becoming redressed, moves around the general axis just named.

Apart from its therapeutic value, this instrument possesses the additional advantage, as the vertebral levers are separate, that the whole spine can be both seen and examined by the surgeon during the time the apparatus is worn.

A still further modification of the foregoing instrument is the power of rotating in a horizontal plane either shoulder; that is to say, if the right shoulder is thrust backwards and the left advanced in an anterior direction, by means of mechanism attached to the plates, a rotatory movement can be effected. This movement has never yet been carried out in any form of spinal support, the only approximation being an apparatus which I invented several years ago for Mr. W. Adams. In the latter instrument an anterior movement was given to the ribs, whereas, in the plan now mentioned, the shoulders and ribs can be independently moved in an antero-posterior plane.

All surgeons who have treated spinal curvature must have become aware of the difficulty which always presents itself in overcoming the projecting shoulder. Frequently after the most assiduous care and perfect restoration of the vertebral column to its true line, deformity of the shoulder remains. This is due to the instrument acting only in a lateral and not an anterior direction. In the improvement I have just described this difficulty is conquered. Hence this apparatus secures the entire series of movements required for the treatment of lateral curvatures, viz.:—1st, rectification of the lumbar curve and restoration of the pelvis to its true horizontal plane;—2nd, reduction of the dorsal curve;—3rd, replacement of the costæ and scapulæ.

Application of the instrument.—The manner of applying the apparatus is as follows: Stand behind the patient, and, opening the pelvic band, place it firmly around the hips in such a manner that the arms rest upon the crutches. See that the two plates rest gently against the arc of each curvature, the vertebral levers having been expanded previous to placing the instrument on the patient's body. Fasten the lacing bands in front, and then gradually tighten by means of the key the vertebral levers. Lastly, see that the arm-slides are at such a height as to maintain the shoulders parallel with the pelvis, and fasten the shoulder-straps. The instrument can rarely be worn more than four hours on the day it is first applied, but after three days the patient readily submits to it, and often feels greatly disinclined to part with the apparatus. Where the patient is young, restoration of the spine to its straight position becomes a perfect certainty, provided that care is bestowed upon the adaptation of the mechanism. The pressure requires to be slightly increased at weekly intervals, and, under no circumstances, should the mechanism be more frequently interfered with. In cases where the patient has almost accomplished her growth it is highly desirable to keep the instrument applied by night as well as day, thus taking advantage of the slight time left for rapid improvement. In adults, great and beneficial change can be wrought in the position of even the worst form of lateral curvature, but it requires a longer time and more care in adjustment than when a younger person is being dealt with. The mechanical action of the instrument is greatly facilitated by causing the patient to recline on a chair such as is figured at page 235, for two hours daily, as by this means additional rest is given, and also the mechanical powers of the instrument are left to exercise a freer influence than when opposed by the constant reaction of the patient's weight and muscular resistance. In cases where I have tried an instrument only, and others where recumbency has also been added, a great difference in progress in favour of the latter course has been observed.

Many apparatuses have been invented by means of which compression can be exercised on both arcs of curvature, but their inventors have invariably failed to recognise the true centres of movement in the distorted spine, and consequently have failed more or less in securing the object they aimed at. A knowledge of the principal forms of apparatus which have been devised for the treatment of double lateral curvature is requisite for the orthopractic student or practitioner; and I propose to describe the different appliances which have been adopted and which are now in use. I shall arrange them in three divisions. The first will include appliances intended to act upon the spine through the medium of recumbency. The second contains those appliances which are intended to remove weight from the spine. The third will include the appliances which afford lateral support, or by means of which lateral pressure is exercised upon the spine.

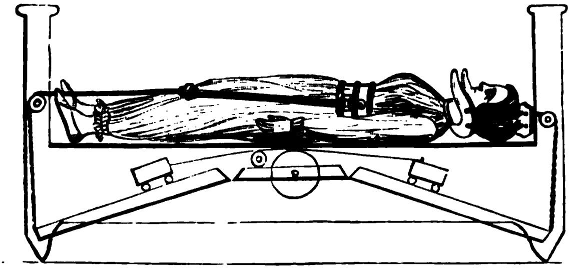
Gymnastic appliances have a place in the section devoted to Debilities of the Trunk.

6. *Appliances intended to act upon the spine through the medium of recumbency.*—All forms of reclining surfaces on which the patient is placed, face downwards, are known as prone, while those in which the patient lies upon the back are called recumbent couches. The celebrated Dr. Darwin first adopted the reclining posture in the treat-

ment of spinal curvature. After Dr. Darwin had promulgated his ideas on the value of recumbency, the method was adopted by Dr. Harrison, whose name it still bears, and who devised a special couch to carry the treatment into effect. Mr. Sheldrake, subsequently, constructed a couch for the same purpose. A brief account of the couches of Dr. Harrison and Mr. Sheldrake, and of their mode of treatment by recumbency, has already been given in the introduction (pp. 65, 66).

A form of apparatus combining recumbency with extension is still adopted in France. It consists of a couch (Fig. 90) on which the patient is laid whilst his hips and head are held by padded bandages fixed to pulleys. These pulleys are acted upon by weights, placed in such a manner as to secure extension between the head and the

Fig. 90.

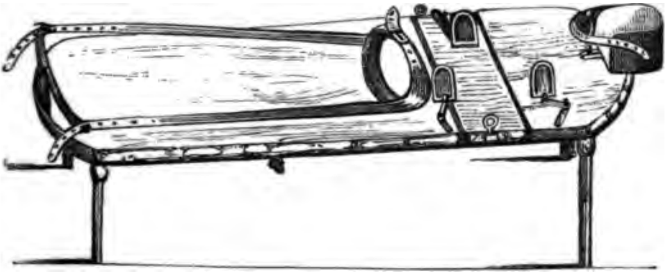


pelvis. With that amount of refined ingenuity always found among our Gallic neighbours, the weights are so arranged that extension can be regulated with the greatest nicety and precision; but, as the principle itself is false in its relation to mechanical science, we may regard the couch as a pretty professional plaything, more than an actual agent for the restoration of spinal curvature.

In Germany a still higher degree of mechanical ingenuity has been exercised in rendering the reclining system available as a means for treating lateral curvature. Not contented with simple elongation of the spine, the Germans also establish lateral pressure against the ribs. These two forces act at the same moment. The following drawing (Fig. 91) depicts a couch I purchased at Vienna seven years ago.

The couch is divided into three parts, the upper corresponding with the cervical, the middle with the dorsal, and the lower with the lumbar curve. The head of the patient is firmly secured by straps to a padded receptacle; the hips are also surrounded by a padded belt, which is fastened by lateral straps to a powerful spring fixed at the end of the couch. Two padded plates, moving by screws in three directions—forwards, upwards, and sideways—are fixed to the margins of the plane; one being attached to the edge corresponding with the dorsal curve, and the other to the edge coinciding with the lumbar arc of deflection. Upon screwing these plates, pressure upon the lumbar region and the ribs at once occurs in opposite directions: that is to say, the dorsal-plate presses the ribs from right to left, whilst the lumbar-plate acts from left to right. At that portion of the inclined surface or plane where the first division takes place, a screw centre is so arranged that upon moving it the two portions separate, as shown in the engraving. There is also a screw centre arranged for the lower division of the couch;

FIG. 91.



but on the margin opposite to the first. The effect of these screw centres is, hinge-like, to open the surface on which the patient reposes, on opposite sides, and as he has been previously fixed by the action of the plates and straps against the ribs, head, and pelvis, the body is acted upon in a direction *antagonistic* to that of the deformity.

By this couch, in fact, an attempt is made to carry out the principle of unfolding curves by pressure upon their apices and expansion of their extremities. The apparatus is ingeniously conceived, and is well-adapted to fulfil the intended object. But the difficulty of inducing the patient to assume a reclining position for a sufficient period, and the injury arising to the health from prolonged recumbency, present insuperable difficulties to the use of this couch; and unless the traction of the apparatus is constantly maintained, it is almost valueless.

Another form of apparatus, constructed on somewhat similar principles, is one used in Paris, its inventor being an ingenious mechanician named Valerius. It is called a "corset-lit" (Fig. 92) and, as its name implies, forms a bed or couch, in which the patient is placed recumbent, and is fixed there by a series of corsets. The apparatus is divided into three sections, moving, by screws, in opposite horizontal directions; whilst elongation is also obtainable at the will of the operator. The head rests in a padded receptacle, A, the position of which can be varied so as to suit the condition of the case, should cervical curvature co-exist with dorsal and lumbar deflections. The thorax is received by a padded shield, B; the lumbar region rests in a movable sheath, C; whilst the pelvis is firmly embraced by the lower part of the apparatus, D.

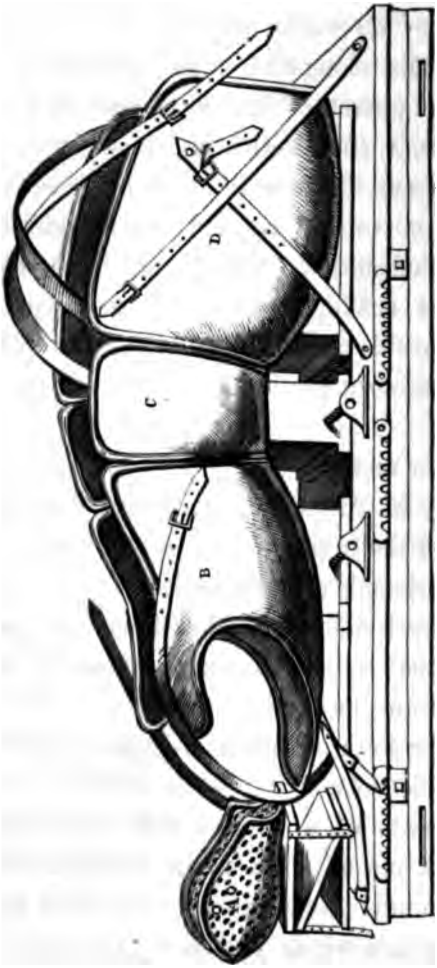
Another modern French couch has been invented by M. Moncour. Extension between the pelvis and the upper portion of the thorax is the leading principle of construction.

This couch differs from that described at p. 279, in this, that extension is made from the thorax and not from the head.

Another form of couch is known as "Coles' Orthopædic Sofa."

It consists of a padded sofa on which the patient is placed in a prone posture. A soft belt surrounds the hips, and terminates by lateral straps in a winch turned by the hand of an

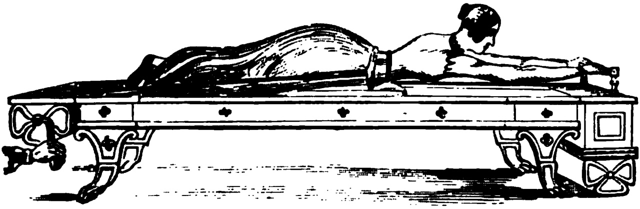
Fig. 92.



For inclination, compression, and extension.

attendant. The hands of the patient grasp firmly a rod placed at arm's length, and extension of the spine is made by means of the winch. This is a very ingenious piece of mechanism for the purpose it is intended to effect.

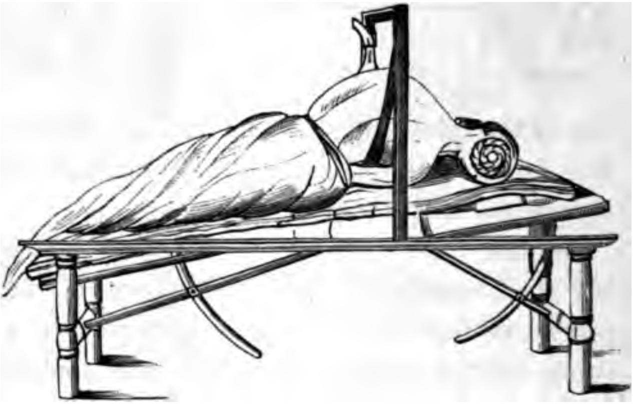
FIG. 93.



Another form of couch is that used by the late Mr. Lonsdale (Fig. 94). The thorax of the patient, in this arrangement, is supported by a swing, but the sustaining surface is only applied to the dorsal arc of curvature, and thus tends materially to increase that curve found in the lumbar region. Mr. Lonsdale fell, as his followers of the present time do, into the error of supposing that only one curve ordinarily existed, and to such an extent was this fallacy carried, that, in all the diagrams given in the little book published by him on the treatment of spinal curvature, the presence of a lumbar curve is, with one exception, entirely ignored.

The couch is made on the same principle as Earl's triple inclined plane, having at its centre two wooden standards, giving attachment to a broad webbing band, which passes across the arc of dorsal curvature.

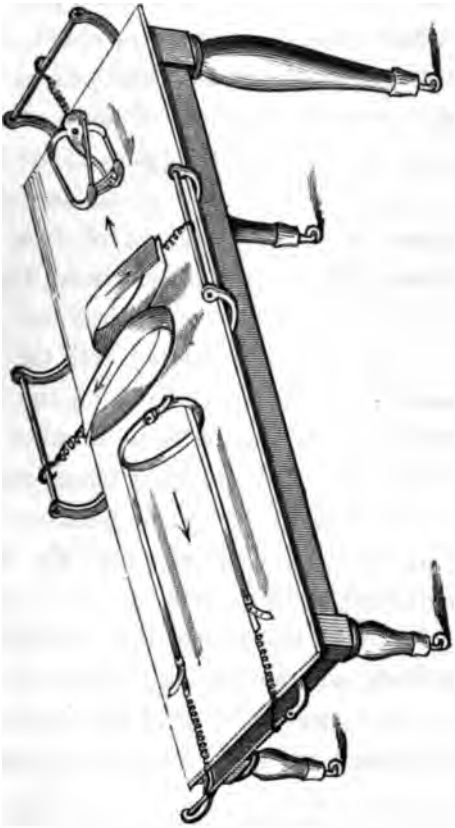
FIG. 94.



The patient is supposed to recline constantly on the side; but this position involves another evil of considerable magnitude, namely, a tendency of the ribs to rotate around their vertebral axes, and thus obliterate the natural curves of the spine. For, although the drawing depicts the right arm as comfortably placed beneath the ribs, it is a position perfectly impossible to be maintained without such disomfort as no patient would long endure: ence the right arm is eventually brought forward and rotation of the ribs ensues.

Several years ago I invented a couch for those

FIG. 95.



cases in which recumbency might be thought advisable. This couch embraces all the appliances which have been practically found of value (Fig. 95). By means of this arrangement extension and lateral pressure can be obtained with a minimum of discomfort to the patient.

The couch consists of a well-padded surface, having a rest for the head, which can be moved obliquely upwards by means of an elastic cord fixed to the upper rail of the plane.

At the lower edge of the plane, another rail is arranged for the attachment of two elastic bands belonging to a padded belt, which is fastened round the hips. Another rail is arranged at the side corresponding with the dorsal curve, and a fourth rail is fixed at the lateral edge of the plane answering to the lumbar curve. To both these rails soft webbing bands are fastened by elastic cords, and these webbing bands pass in antagonistic directions over the arcs of dorsal and lumbar deflections.

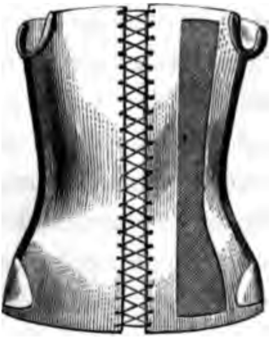
The advantages attached to this invention are, that the body can move in any direction. The only restraint exercised being by the elastic cords, which, although allowing freedom of motion, exercise a constant retractile force in a direction opposed to the curves.

7. *Appliances for removing weight from the spine.*—The second group of apparatuses embraces all those intended to remove the weight of the head and shoulders from the spine, by transferring it to the pelvis. No sooner did the evils resulting from continued recumbency, as practised under the systems of Darwin and Harrison, become clearly apparent to the profession and public, than agencies were sought which might enable the patient to take ordinary exercise, and yet find relief from the superincumbent weight of the head and shoulders. For, as the spinal column is less capable of sustaining the natural weight of the head, in proportion to the transverse area of the abnormal vertebral curves; so whatever is calculated to support the head and shoulders, and thus considerably diminish the gravital force of the whole superior mass, gives mechanical aid of no slight value.

The first form of support constructed to achieve this object was an ordinary stiffened stay, the whalebone sides of which received and supported the thorax, conveying a considerable portion of its weight to the pelvis, on which the stays rest.

As, however, stays simply thickened with whalebone readily change their shape laterally, when subjected to long-continued bodily warmth, more harm than good constantly resulted whenever the form of the stay became coincident with the concavities of the different lateral spinal curves. Under these circumstances, the stay simply confirmed and maintained the deformity, without in the least degree ameliorating it. An evident improvement upon this plan, therefore, was the introduction of lateral metal crutches, so arranged that the arms rested firmly on the upper surface, while the hips were embraced by their inferior terminations (Fig. 96). The crutches were made to elongate, so that the one next to the

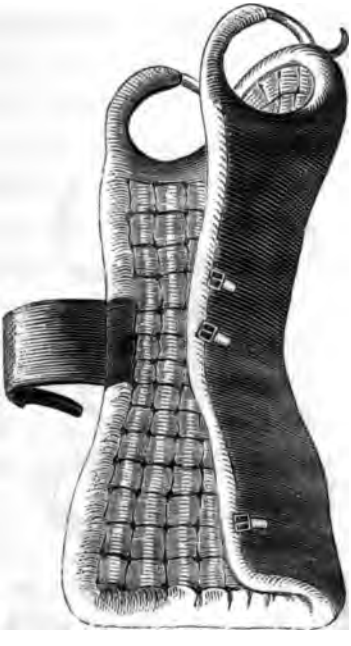
FIG. 96.



icavity of the dorsal arc could be raised higher n its fellow on the opposite side. Besides lateral uprights, a padded plate of thin metal s frequently introduced, for the sake of adding ngth to the retaining surfaces.

As stays required a great deal of care in king them fit the body properly, and were ely even then productive of such support as

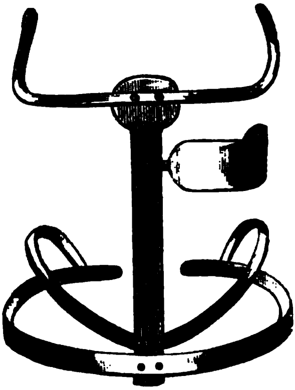
FIG. 97.



some cases of great muscular debility demanded, a padded metal shield was strongly advocated by French surgeons (Fig. 97).

Another instrument, at one time very extensively used, was that adopted by Sir Astley Cooper. It has furnished the basis for a large number of apparatuses, which will be found described in these pages, and, with slight modifications, has been made to serve the name and purpose of almost all the practitioners who first began to make the treatment of deformities their speciality (Fig. 98).

FIG. 98.

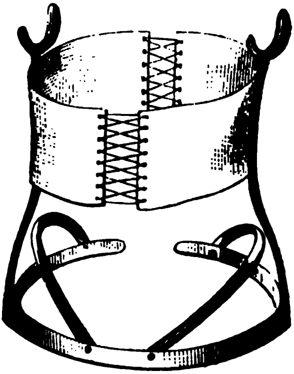


It is formed of a pelvic band which encircles the hips, and which is retained more firmly in position by two oblique metal bands, which rest on the crests of the hip bones. A vertical stem softly padded, and forming an artificial spine, springs from the pelvic band. To the upper extremity of the stem a horizontal bar is attached, the ends of which, being bent forwards, form arm rests. To the lateral margin of the back stem a plate, which is applied against the prominent ribs, is attached, and being formed as a spring, maintains constant rotative action against the ribs. This proves that at the period when this instrument was invented, rotation of the ribs on the bodies of the vertebræ was known and guarded against. Indeed, although some modern writers mention horizontal costal rotation as a recent anatomical discovery, its existence has been recognised for at least fifty years, and the distortion caused by it mechanically treated.

Another form of appliance for removing the weight of the head and shoulders, and placing it on the pelvis, may be described as follows (Fig. 99):

A pelvic band, with oblique hip supports, carries two lateral uprights, which receive the weight of the upper portion of the trunk. A

Fig. 99.



soft lacing-band connects the uprights before and behind. As no pressure is exercised upon the spine by this instrument, it is well adapted for use where spinal irritation exists. Where the spine requires more than usual support, the lateral uprights are prolonged at their lowest margin, so as to rest against the seat of the chair when the patient is in a sitting posture.

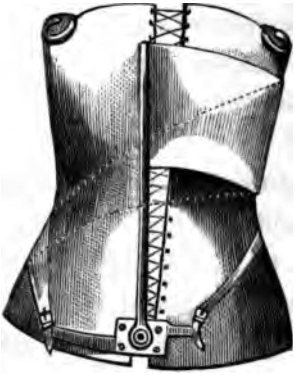
The appliances which have been described represent the most important forms of apparatus for removing the superincumbent weight of the head and shoulders from the trunk, and transferring it to the pelvis. It may, however, be stated, that the instruments described for the relief of cervical curvature (Chap. I), can be used for this purpose. They are particularly adapted to those cases where it is thought advisable to support the head.

9. *Appliances for affording Lateral Support to the Spine.*—In the third group of instruments for the treatment of double lateral curvature are included those which not only remove the weight of the head and shoulders, but which also tend, by acting against the antagonistic dorsal and lumbar arcs, to depress their highest points, expand their extremities, and restore the vertebræ to a normal line, by gradually obliterating the areas embraced by the opposing lateral concavities.

The apparatuses belonging to this division are deservedly held in higher favour than those described in the preceding section. Amongst them will be found some that exercise lateral force; others act in a rotatory direction; whilst some, again, combine both lateral and rotatory action.

To commence with the simplest apparatus. A form of appliance may first be described which is easily attached to ordinary stays (Fig. 100). It consists of a vertebral lever, fixed into the four bottom lacing holes of the stays by a small metal plate which has at either side a prolongation to secure steadiness and afford attachment to the extremities to two webbing straps. At the upper extremity of the stem, over the dorsal curvature, a deep webbing band is fixed, which passes across the front of the body and is secured behind to the plate which holds the stem in the stay-holes.

FIG. 100.

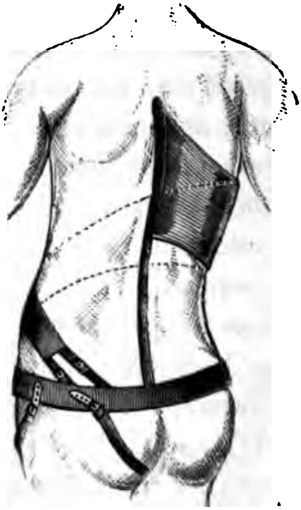


This form of instrument is extensively used in India, from its lightness and the facility for concealment. It acts upon the spine by producing a constantly tractile force against the highest point of the dorsal curve, whilst the lumbar curve is reacted against by the stiffened substance of which the stay is made. The greatest advantages of the instrument consist in the ease with which it can be adapted to the ordinary stay and worn unobserved. It is of value in cases of slight or incipient distortion, as, since the webbing band always acts against the convexity of the curve only, respiration is unimpeded.

The next form of instrument is somewhat similarly constructed, but owing to its not furnishing any counteracting influence on the opposite side of the support, it is calculated to prove highly injurious to the patient who wears it. As it has, however, been strenuously recommended by several writers on spinal curvature, it is figured in these pages (Fig. 101).

A broad pelvic belt which encircles the hips has an oblique vertebral stem attached to it. At the upper part of this stem, and corresponding with the highest point of the dorsal curve, a webbing band passes around the chest and across the abdomen, and is fastened to the pelvic band behind. In order to prevent the pelvic band being displaced vertically, a leather strap is passed around the left thigh. It is clear that directly force is exercised upon the dorsal curve by means of this instrument the concavity of the lumbar deflection must be increased, and consequently,

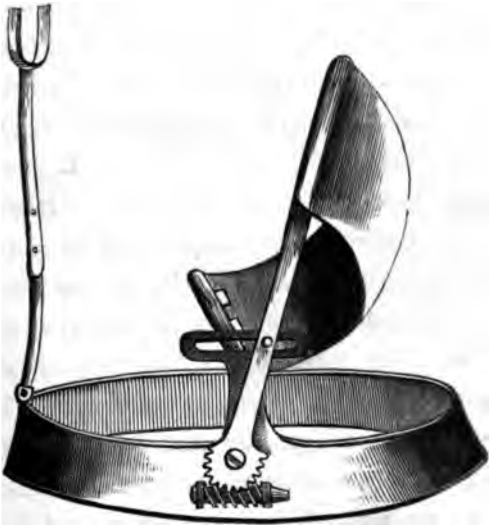
FIG. 101.



the lower arc of distortion. For as each curve tends to antagonise the other, so diminution of one arc of distortion, unless effected at the same time with that of the compensatory curve, must lead to an aggravation of the latter. Thus, even admitting the possibility of relieving the dorsal curve by this appliance, this could only be gained at the expense of an increased lumbar distortion, no counteractive force being exercised on the lumbar curve. The instrument bears the name of Hosard or Tavernier's "Belt," both claiming its invention.

Another apparatus, similar in principle, and marred also by the mechanical error just pointed out, is that known as Mr. Lonsdale's "Spinal Machine," which is evidently a modification of Tavernier's plan of procedure. The following (Fig. 102) is a drawing of this apparatus, taken

Fig. 102.

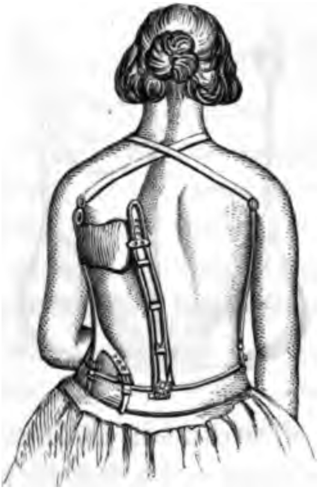


from the second edition of his work on "Spinal Curvature" (p. 81).

One advantage possessed by this appliance over its prototype, is the adaptation of a lateral crutch to the side corresponding with the dorsal concavity, by which means tilting of the pelvic band becomes much lessened. But there is still no provision made for encountering the certain increase of the lumbar curve, should pressure only be made upon the apex of the dorsal arc. There cannot be the least doubt but that the use of this apparatus, in a case of double lateral curvature, would be followed by failure. The principle upon which this kind of apparatus is constructed, being so decidedly erroneous, it is surprising to find that it should still be adopted. The following drawing (Fig. 103) represents an instrument much advocated and in constant use. It will be perceived that with the exception of substituting a metal plate for the webbing band, it is precisely similar in construction to Tavernier's Spinal Machine.

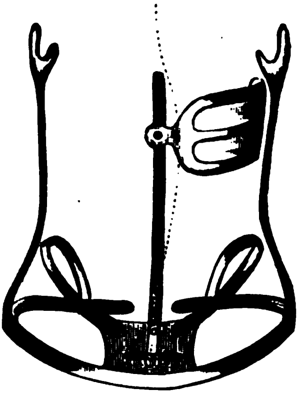
Another form of instrument, depending for its mechanical value upon the force exercised against the dorsal arc, is one which, more than any other, has, on account of its light construction and

Fig. 103.



simple form, been adopted by some of our most eminent surgeons. It was invented by the late Mr. Eagland, a clever London mechanician; and apart from the error of only counteracting one curve, instead of seeking to antagonise both, deserves the highest credit. It is composed, as will be seen by the diagram (Fig. 104), of a well-fitted pelvic band, with two lateral supports for the arms. At its posterior pelvic centre a metal plate is fixed, giving attachment to a vertical lever, which has a horizontal screw for the due

FIG. 104.



adjustment of mechanical pressure. The lever carries at its upper part a shoulder-plate.

If the dorsal curve be primary, or the lumbar offers no considerable degree of prominence, this instrument answers well; but if perchance the dorsal curve has secondary origin, then the evil mentioned as pertaining to an instrument having but one vertebral plate arises, and retrogression, instead of improvement, results.

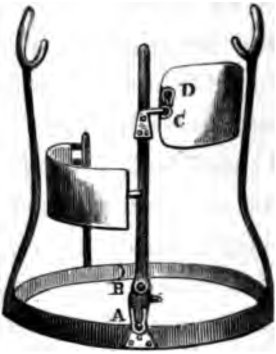
Before dismissing those appliances which act solely on the dorsal arc, it is well to remark that, in the event of the dorsal curve originating first, these instruments, although faulty in design, lose a good deal of their mischievousness. This circumstance accounts for the cures which we occasionally hear of, in consequence of the adoption of these imperfect mechanisms. But if it be assumed that the dorsal curve has in such cases been the primitive one, the cure would have been accomplished in less time if pressure had been applied contemporaneously upon the lumbar distortion.

The form of instrument which I am now about to describe was invented by myself for Mr. W. Adams. It was especially devised for overcoming rotation of the vertebral column—a condition present in a greater or less degree, in *every* case of lateral curvature, as Mr. John Shaw and Dr. Dods asserted some time ago. Mr. Shaw described lateral curvature as "serpentine."

The instrument consists of a pelvic band sustaining two lateral uprights and a vertebral stem which carries a shoulder-plate (Fig. 105). In the construction of the vertebral stem and shoulder-plate the peculiarity of the mechanism consists. The left lumbar plate with anterior stem, shown in the diagram, were subsequent additions, and the reasons for their addition will be given presently.

At the base of the back lever, where it joins the pelvic band, two centres of movement are

FIG. 105.



placed, one (A) acting anteriorly, the other (B) in a lateral direction. Thus, on moving the former, pressure of the plate forwards against the shoulder is caused, and on moving the latter, lateral pressure against the ribs. The plate itself also has two centres of movement; one (C) corresponding with the horizontal rotation of the ribs on the spine, and the other (D) moving the plate in a vertical direction around its centre of attachment. By means of the horizontal shoulder movement (C) it was sought to act upon and re-rotate the ribs in an anterior direction. A controlling pressure was exercised upon the curvature by the movement (B) at the base of the vertebral lever. The shoulder itself was attempted to be depressed by the action of the vertical axis (D) in the shoulder-plate.

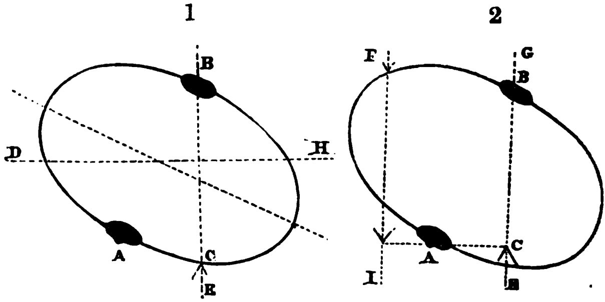
I gave considerable pains and attention to the invention of this instrument, but it was soon evident that it was defective in several points. To render these defects clear, it will be well to premise an explanation of the effect which follows any attempt to rotate a deformed spine, without guarding properly against mechanical reaction upon the human thorax.

By rotation of the spine that condition is generally understood wherein the ribs move on the bodies of the vertebræ in a backward direction; but as no deviation can ever occur in the spinal column, either transversely or laterally, without a compensating curve being established in an opposite direction, so whatever amount of rotation takes place in the ribs at one portion of the spine (say, for instance, in the dorsal), must be accompanied with an equal amount of displacement, but in an opposite direction (in the lumbar region).

In addition to this, the upper portion of the thorax, which in its natural condition forms in its transverse plane an ellipse, the longest axis extending between each side of the body, changes its direction, and assumes a new shape, shown in the accompanying diagram (Fig. 106).

Fig. 1. A, represents the spine; E, the point

FIG. 106.



where the plate of the spinal instrument has its horizontal movement; B, the sternum; C, the rotated ribs in the dorsal region on which the rib-plate of the instrument rests; D H, the original axis of the thorax; E B, the direction of force given to the ribs when the apparatus I have described is brought into action.

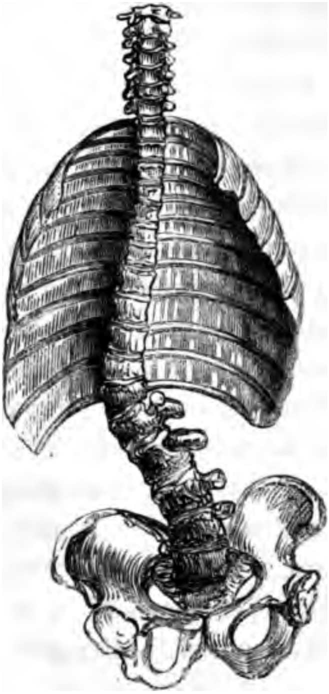
It is evident that when the *single* force, E B, is brought into operation for the purpose of rotating the displaced ribs into their normal position, the entire thorax becomes thrust forward without in the least degree diminishing the curvature against which the mechanism is supposed to exert itself; so that instead of the ribs rotating around their vertebral axis, A, they will advance, accompanied by the whole dorsal vertebræ, in the line E B.

To meet this imperfection in my design, it was necessary to modify the construction of the apparatus so as to obtain pressure in a posterior direction upon the opposite side of the thorax. This was effected, as shown in diagram 2, Fig. 106, by attaching to the instrument employed a carefully devised plate, which rests against the antero-lateral surface of the thorax, F, and re-acts against the shoulder-plate. The direction of this plate is shown in the dotted line I. By this means actual re-rotation of the spine at A can be properly secured; for as the distance between A I and A C are equal in relation to the point A, and the forces employed—viz., F I and and E B—are in opposite directions, the ribs are rotated around their vertebral axis, which is the object to be accomplished.

In proof of the spine undergoing rotation in opposite directions in the lumbar and dorsal regions, I would refer to a specimen of double lateral curvature, accompanied by severe rotation, now in the museum of St. George's Hospital.

In this case the vertebral bodies composing the upper segment of the dorsal curve are rotated backwards; those forming the inner segment of the lumbar deflection are also rotated backwards, whilst, between the centre of the two curves, an anterior rotation of the vertebræ is exhibited. The following sketch (Fig. 107) is taken from the specimen. It serves to illus-

FIG. 107.

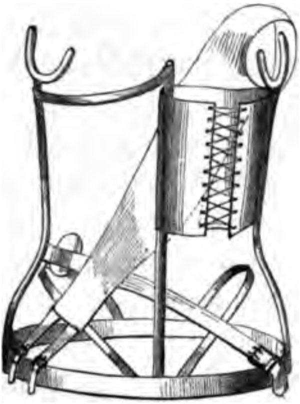


trate the fault committed in employing rotative force against the upper curve, without securing counteraction at the anterior surface of the ribs on the opposite side of the sternum.

The next form of apparatus (Fig. 108) is one invented by Mr. Laurie, and calculated to prove of great service in cases of ordinary double lateral curvature; one of the best proofs of its merit being that it was extensively adopted by Sir B. Brodie, for whose patients, and at whose wish, I constructed a large number of these instruments.

The apparatus consists of a padded pelvic belt, with two semi-lunar bands passing over the

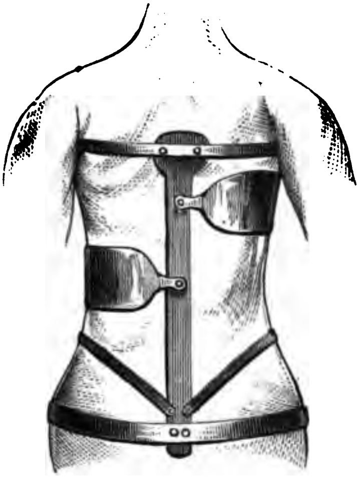
Fig. 108.



crests of the hip-bones. To this pelvic belt two lateral uprights and a vertical stem are attached; the latter being connected to the left upright by a horizontal bar passing across the corresponding shoulder, which gives stability to the whole structure. Passing over the right and uplifted shoulder is a lever cap, which is fastened obliquely by two straps to the pelvic belt. Against the protruding ribs there rests a lacing band, very softly padded, the pressure of which can be augmented at will. Over the centre of the lumbar curve a pad and oblique strap is placed, by the tightening of which diminution of that curve is brought about. In order to prevent the body escaping from the apparatus, and thus displacing the surfaces of posterior resistance, a soft linen band crosses the chest. This form of instrument can be easily concealed beneath the tightest dress.

A very simple apparatus (Fig. 109), intended to act against both arcs of lateral curvature, was suggested by my predecessor, Mr. Sheldrake; and has evidently been the prototype of a large number of modern inventions. It is constructed as follows:—a pelvic band, shaped to the hips and resting upon the ilia, gives attachment to a vertebral stem, which terminates superiorly in two horizontal arm-pieces, sliding upward in a vertical direction. Fixed to the margins of the vertebral stem, are two light padded plates, which, being tempered like a watch-spring, grasp the body and create pressure against the arcs of both lumbar and dorsal curves—much as the human hands would, if employed to press the sides of the body in opposite directions. To bring this instrument into proper action, the left arm-piece should be raised above the level

FIG. 109.



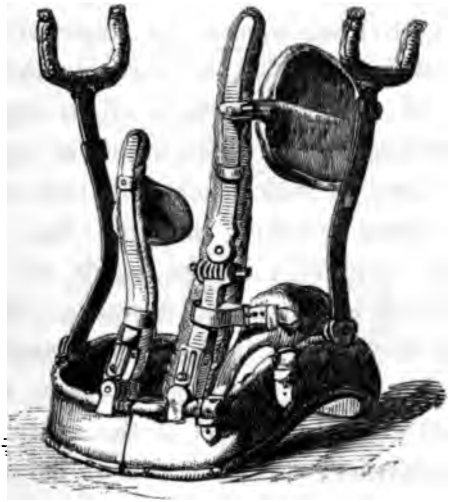
of the right, so as to uplift the depressed shoulder; whilst the two plates should be gradually tightened up to the highest point of pressure that the patient can bear without discomfort. This extremely light and ingenious piece of mechanism is constantly employed by me in cases of slight or incipient curvature, and with the best possible results.

In some of the instruments which have been constructed in imitation of the foregoing, the desire to diminish curvature, by compression of the lateral arcs, has been carried to an absurd and injurious extent, displaying a curious ignorance of the mechanical principles involved.

The following is a description of an instrument which I removed from a young lady aged fourteen years, the daughter of a celebrated orthopædic surgeon. The instrument weighs no less than eight pounds (Fig. 110). It consists of a very deep and clumsy pelvic band, having two back stems fixed to its posterior centre, one of which stems supports a plate resting against the lower or lumbar curve, the other carries a plate acting against the upper or dorsal curve. Both plates can be moved laterally by means of a ratchet-centre.

Two lateral uprights, as in almost every ordinary form of spinal instrument, carry arm-rests. The arrangement of the two ratchet-joints having no mathematical relation to the centre of the vertebral curves, as in the instrument described at Fig. 106, only served, when brought into action, to force the ribs towards the spine in a lateral direction. But as the resistance offered by the ribs is less than that presented by the spine, it would happen that the enormous force exerted by so

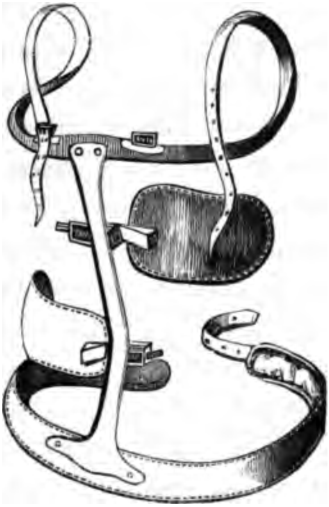
FIG. 110.



powerful an instrument would induce a flattening of their surfaces. I have seen a perfectly sharp ridge upon the ribs at their angles, induced by constant application of this special kind of mechanism. Another objection is, that since the lower ratchet moves, not only the dorsal plate but the axis to which the dorsal plate is fixed, a disturbance of the fixed centre shown to exist in all double vertebral curves (see Fig. 87) occurs, and the power of the instrument is expended in lessening the lateral space of the ribs instead of in expanding the vertebral curves. The use of an apparatus of this kind, of which unhappily there are still some forms adopted, requires the greatest caution. Although in the hands of persons accustomed to watch, and counteract, those abnormal disturbances which might result from the action of the ratchet-joints, cases may be apparently improved; yet if the instrument is used injudiciously, compression of the ribs and its attendant evils will inevitably follow.

A somewhat similar form of instrument (Fig. 111), acting by lateral compression, has also been largely employed in spinal treatment. It consists of two crutches supported by a vertebral lever attached to the sacral centre of a pelvic belt. On either side of this "artificial spine" a plate is arranged, the upper resting against the arc of the dorsal, the lower against the lumbar

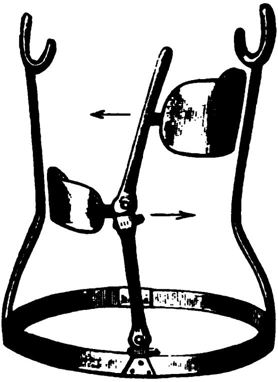
FIG. 111.



curves. Motion is given to these plates by means of a horizontal screw, which, by being thickened in the form of a wedge at its end, produces a certain amount of rotation; or rather, *theoretically* does so, when applied to the ribs. Upon carefully examining the action of this apparatus, the merest tyro in mechanics will discover that, as the spine possesses anterior mobility, whatever amount of force is exercised in forward direction by the plates, must of necessity drive or push the body out of the apparatus, and end by producing lordosis, or hollowing of the lumbar vertebræ, instead of conquering the lateral deflection for which it is intended to be used. This instrument, like the one previously described, shows the liability to mischief which arises from an ill-devised mechanism.

An instrument can, however, be made to act by lateral compression in an efficient and scientific manner, as may be seen by the following example (Fig. 112). This instrument was invented by myself. Its object is to secure mechanical movement from those points which correspond with the fixed centres, observable in all cases of lateral curvature, namely, in the sacro-lumbar region, and at the axis arising from the junction of the lumbar and dorsal curves. It has a pelvic band and two lateral uprights, with the usual form of back stem. This vertebral lever has two axes: one coincident with the point of junction of the upper and lower spinal curves; the other with the

FIG. 112.*



sacro-lumbar articulation. A padded metal lumbar plate is fixed to the former centre; and another, which rests upon the enlarged ribs belonging to the dorsal curve, is arranged on the opposite side. On moving the sacro-lumbar centre, the plate on the left side produces diminution of the lower curve; and on bringing into action the ratchet which corresponds with the junction of the lumbar and dorsal curves, a lessening of the dorsal arc ensues: thus the spine becomes gradually restored with but a slight expenditure of mechanical power. For cases in which the spine has recently yielded, this form of apparatus is of great service.

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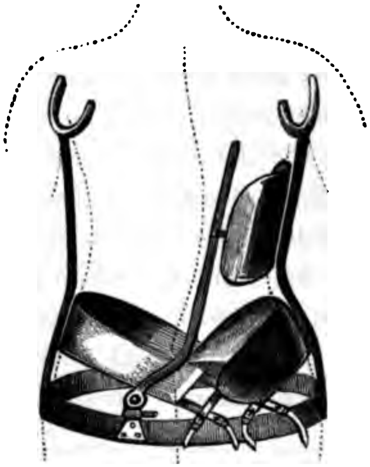
* I first devised this apparatus for a patient of Mr. Fergusson's. In this case it succeeded in perfectly straightening the spine.

Sometimes, in old standing cases of lateral curvature, so great an amount of costal displacement exists as to require the application of an uplifting power to the lower segment of the curve. I have invented an extremely simple plan for obtaining this desideratum (Fig. 113).

FIG. 113.



Instead of the back stem being made to represent a vertical line, it is formed with an abrupt curve in its lower portion, the effect of which is to produce an uplifting of the plate whenever lateral force is engendered. For, as the centre is placed beyond the line of the vertebræ, an increase in radius occurs, so that the costal plate, instead of travelling in a horizontal direction, rises upwards, carrying the bulged ribs with it, and thus diminishes the area of the dorsal curve. A webbing band passes over the left hip, and secures a certain amount of reaction against the lumbar deflection. This was the first instrument which gave me an insight into the advantages derivable from a curved vertebral lever, the elaboration of which for double lateral curvature is described at page 270.

The next instruments which I shall describe are based upon a principle entirely my own. They offer the rare advantage of permitting free muscular movement to take place, during the whole of the period which they are worn. The cause which led to their invention was the necessity that appeared to exist for such an application of mechanical power to the treatment of spinal curvature as would admit of perfect bodily freedom. Every form of instrument with which I am acquainted limits muscular motion, and in many cases entirely suspends it. To overcome so formidable an objection taxed all my powers of invention; and it was not until after making a long series of mechanical experiments, that I at length arrived at the conclusion that in the retractile force of vulcanized india-rubber was to be found an agent capable of accomplishing all that could be scientifically desired.*

The first instrument constructed on this plan consists of a pelvic band giving attachment to a vertebral stem and two horizontal arm-pieces.

In the arrangement of this vertebral stem the whole mechanical merit consists. It is jointed in such a manner as to assume any position which the body offers, whilst two plates, one for the dorsal, the other the lumbar curve, are attached to its sides. Fixed to the left arm-piece, which also moves upon a vertical centre, is a strong vulcanized india-rubber cord, which passes over a roller in conjunction with the dorsal plate, and again over another roller attached to the lumbar plate, and is firmly fixed to the pelvic band. On drawing this cord tightly downwards

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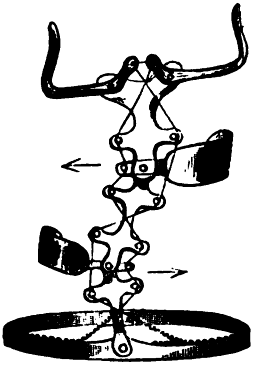
* For nearly ten years I have applied the elastic force of india rubber to the treatment of club-foot and spinal curvature with the most beneficial results.

This plan has recently been made the subject of a special work and mode of treatment, without, however, any acknowledgment being made as to the source from whence it was derived.

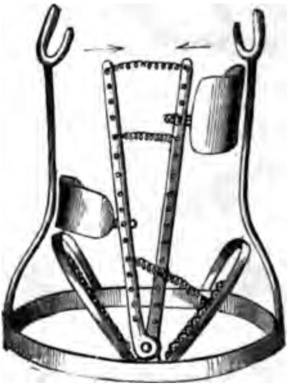
FIG. 114.



by a buckle and strap, it instantly acts upon the yielding artificial centres, and induces powerful and equal compression of the lumbar and dorsal curves. Although the force employed is considerable, yet, from its elastic and resilient character, it permits the body to move freely in every direction. By the persistent action of the elastic force the vertebral curves are gradually diminished, and a restoration of natural equilibrium is established. With this form of instrument respiration takes place freely, and the patient feels hardly any restraint from its use.

Another form of spinal support, based on the same plan, is thus constructed: its employment being intended for cases of average severity. A pelvic band encircles the hips, whilst two lateral uprights remove the superincumbent weight of the head and shoulders from the spine. On each arc of curvature a metal plate rests, held by two levers which move freely on a common centre.

FIG. 115.



By fixing india-rubber cords from the centre

ach plate to the adjacent parts of the instru-
nt, compression of the deformed surfaces re-
ts; but with the advantage, attributed also to
former instrument, of allowing the patient
breathe and move about freely during the
ole period of treatment.

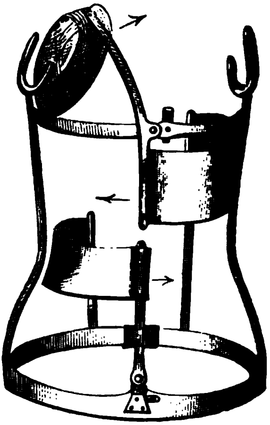
I constructed six distinct forms of apparatus
this elastic plan, and found that they all ful-
ed their purpose with a certain degree of
iciency.* I refrain from giving drawings of
other four, as they were only modifications
those just described. It cannot, however, fail
strike the professional reader that, with a
bstance so easily regulated as india-rubber,
sufficient amount of mechanical force can be
tained without fear of producing abrasion or
itation of the skin; whilst, from the persistent
ion of this force, the muscles and ligaments
posed to the restoration of vertebral equili-
ium, must eventually become fatigued, and
is yield to the power applied to negative and
ercome their resistance.

Before dismissing this branch of my subject,
would give a description of two other forms of

I am deeply indebted to Mr. Erichsen for kindly afford-
me an opportunity of trying this plan of elastic force.

spinal instrument which have proved highly valuable for redressing the vertebral arcs. The first is constructed as follows (Fig. 116):

FIG. 116.

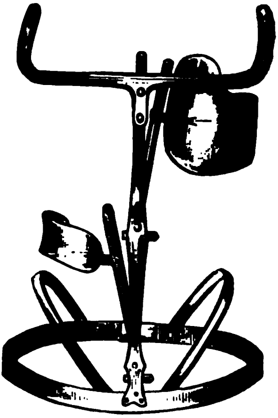


A pelvic belt and two lateral uprights form the base of the structure; the uprights being connected together at their highest point by a horizontal band of steel passing across the shoulders. In the centre of this band two ratchet axes are fixed, one giving an uplifting movement to a lever which holds a padded ring, through which the left arm of the patient passes. Another ratchet-centre, immediately below the first, moves laterally. A webbing band passes over the dorsal curve, and is firmly fixed to a front stem. A third ratchet-centre occurs in the middle of the pelvic belt, which moves a lever fixed to a webbing band passing over the lumbar curve; and this webbing band is also fixed to a front upright. The action of this instrument is simple, but excellent; for upon moving the upper shoulder ratchet, an uplifting of the left arm and expansion of the dorsal curve ensues. On moving the lower shoulder ratchet, a tightening of the webbing band and diminution of the arc of dorsal curve takes place; and on moving the pelvic ratchet, a depression of the lumbar arc is secured. These include the whole of the conditions required to restore a deflected spine to its original position.

The second instrument is intended for use when the patient is anxious that the mechanism should be concealed from observation (Fig. 117). Its only difference consists in the absence of lateral uprights, and the substitution of a horizontal arm-piece.

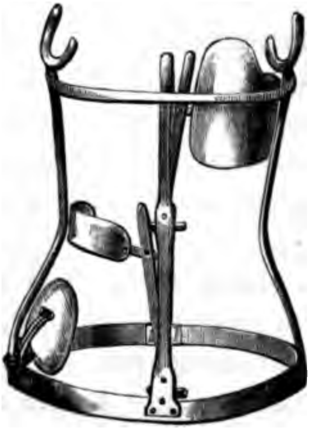
Sometimes one of the ilia may be so much displaced as to prevent the lumbar plate of the preceding instruments acting perfectly. For overcoming this condition I have adopted the

FIG. 117.



following arrangement (Fig. 118):—It consists in the application of a padded plate resting

FIG. 118.



against the lateral surface of the displaced ilium, and acting by means of a ratchet-joint in a direction calculated not only to depress the upraised side of the pelvis, but, what is far more important, entirely prevent any displacement of the mechanism, and increase greatly the force of the upper or dorsal plate.

9. *Deformities of the pelvis.*—Under this head are included obliquity of the pelvis and a tilting forwards of one or other hip.

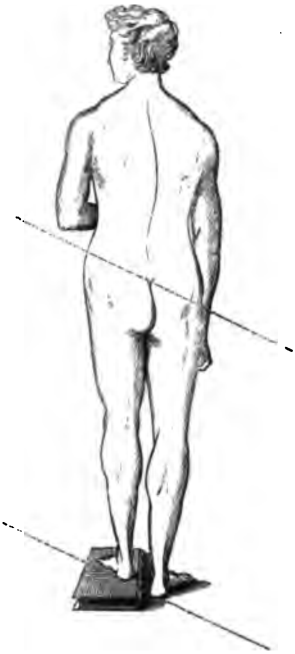
Obliquity of the pelvis frequently arises from lumbar curvature, and when dependent upon other causes is itself a source of spinal curvature. The chief cause of obliquity of the pelvis is a shortening of one leg from whatever source arising. When a difference in the length of the two legs exists, the pelvis is necessarily thrown out of its horizontal position. As a further consequence the normal relation of the spinal column to the pelvis is disturbed, and the maintenance of the head in a just equilibrium is only possible by the formation of two or more lateral curves, in the manner already shown in the section on double lateral curvature.

In determining the cause of obliquity of the pelvis, the first thing to be done is to ascertain the length of the legs. For there is an apparent as well as a true shortening of one or other leg, and the remedy for the latter deformity would exaggerate the cause of the former. For this purpose the patient should be placed at full length on the back, and the distance measured between the anterior superior spinous process of the ilium and inner malleolus of each limb. If a difference be found in the length of the two limbs, it is certain that the obliquity of the pelvis is dependent upon shortening of the defective limb, and not upon lumbar curvature. If, however, the legs be found of equal length, then the deflection of the pelvis will be due to distortion of the spine.

The mechanical remedy for obliquity of the pelvis when it arises from shortening of a leg is a thick-soled boot, the thickness of the sole supplying the deficiency of length in the shortened leg. The exact amount of difference between the two legs being determined, the sole of the boot is made of a thickness equal to the difference. It is important that the whole of the sole should be raised to this extent, and not the heel alone, else contraction of the heel tendon would be induced.

If the obliquity of the pelvis depends upon spinal curvature, any attempt to remedy, by means of thick-soled boots, the apparent shortening of a leg which is then observed would aggravate the spinal mischief. In the accompanying diagram (Fig. 119), the apparent shortening

FIG. 119.

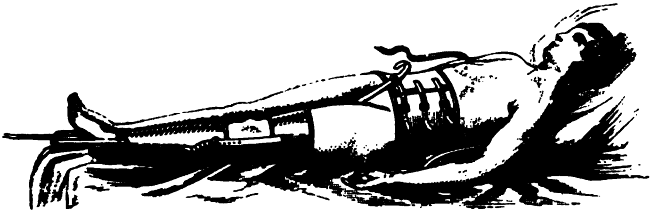


of one leg from obliquity of the pelvis arising from spinal curvature is shown. It is seen that the diminished length of the apparently shortened limb depends upon the tilting up of the pelvis on the same side. It is also clear that to interpose a substance of thickness proportionate to the apparent difference of the two legs between the sole of the seemingly shortened leg and the ground, would solely add to the mischief already present, by maintaining, if not exaggerating, the original cause of distortion. In such a case, in addition to the means more directly employed for remedying the spinal defect, it is only permissible to attempt to depress the tilted pelvis, by attaching a weight to the leg or by direct traction.

The weight may be fixed to the boot or otherwise, and the patient is not allowed to walk except on crutches. By this means it is occasionally found that a gradual depression of the tilted pelvis and apparent lengthening of the leg takes place.

In applying traction the same means of extension and counter-extension may be adopted as are used for fractures of the neck of the thigh. The counter-extension must be exercised upon the unaffected side. M. Bonnet describes an ingenious arrangement for fixing the pelvis and obtaining a firm grasp upon the shortened limb for the purpose of traction. To secure the former object, a broad belt surrounds the body (Fig. 120), a strap passing beneath the limb which is not shortened. By means of this strap the pelvis can be fixed firmly to the bed or couch, or to a special apparatus such as M. Bonnet describes. The thigh strap provides for counter-extension. To secure the second object, the thigh and leg of the tilted limb are surrounded by a well-padded leather sheath connected together by side straps. Two iron bands project beyond the foot from the lower border of the leg-sheath, and are connected by a transverse rod, by means of which the extending force is conveyed to the limb. The

FIG. 120.



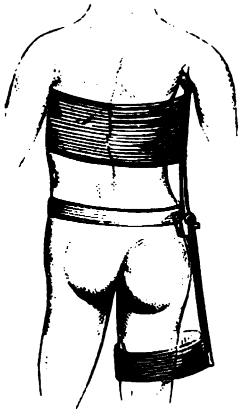
sheaths enable this force to be effectively applied, and prevent injury to the tissues.

M. Mayor, who, Bonnet tells us, has comprehended better than any other authority, the indications for treatment of lateral deviations of the pelvis, was accustomed to use energetic traction. Many facts cited by him, says Bonnet, show that, by the aid of the means he proposes, a limb shortened many centimètres, as if from spontaneous dislocation, can be fully extended. M. Mayor used a special apparatus for the purpose of extending and fixing the leg, a description of which, and of the method of using it, will be found in his work, *Excertricités chirurgicales* (1845).

A more scientific and satisfactory mode of attaining the same object is afforded by an ingenious American invention.

It consists, as will be seen by the following diagram (Fig. 121), of a metal stem articulated laterally at the hip, and furnished with a stop-joint so arranged that it prevents the thigh lever from becoming perpendicular. The upper extremity of this lever is secured by a laced webbing band to the chest, whilst the lower one is fastened to the thigh by a padded metal trough. The pelvis is also encircled by a padded strap, cor-

FIG. 121.

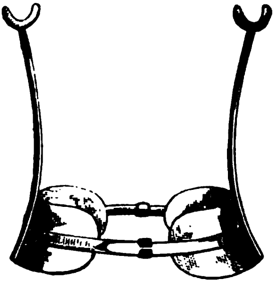


responding with the centre of articulation in the instrument.

When this instrument is applied it has a tendency to draw the thigh of the longer leg in an outward direction; and this, since it renders walking impossible until the shortened leg is replaced in its natural position, leads to an uplifting of the depressed side of the pelvis, which is the object aimed at.

There is a variety of pelvic obliquity characterised by a tilting backwards and upwards of the posterior or coccygeal region. This may be induced either by relaxation of the ligaments which retain the thigh bones in their sockets, or may arise from disease or accident, the margins of the osseous cups in which the thigh-bones rest being broken or injured. The walking of a patient thus affected is distinguished by an uneven, rolling motion, which leaves an impression that the walker's body possesses telescopic articulations. To counteract this condition, I usually adopt the following apparatus.

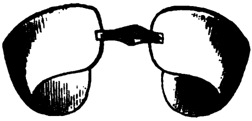
FIG. 122.



Two lateral sliding uprights receive the weight of the body, taking their bearing under the arms and transferring it to a deep pelvic trough carefully moulded to the hips. Within this trough, and just above the head of the external trochanters of the thigh-bones, hard, semi-lunar pads are placed, and are held in position by a band of steel accurately fitted to the pelvis, and grasping the whole of it firmly. Between each leg a padded strap passes, which secures the leathern trough in such a manner that upward displacement is rendered impossible. When this apparatus is adjusted, the patient's weight, instead of being received by a yielding pelvis, rests entirely upon the projecting trochanters: and the pelvis is again restored to that condition of solidity which is demanded for the due fulfilment of its mechanical functions.

Sometimes the pelvis is distorted by horizontal displacement of the ilium; that is to say, by a projecting forwards of one hip anteriorly unaccompanied by shortening of the limb. This condition, although most frequently found in combination with spinal curvature, sometimes exists alone. When this is the case, the apparatus adopted is formed of two padded steel plates, hinged behind, and furnished with a rack and pinion-screw, so placed as to rotate one half of the instrument in a backward direction. That side of the pelvis which is in the best position is thus made a fixed point for mechanical action, and the anterior surface of the opposite hip, being grasped, is dragged backwards, and at the same time is rotated upon the spine (Fig. 123).

FIG. 123.



The tendency to curvature of the spinal column which necessarily arises from disturbance of the horizontal plane of the pelvis, makes it a matter of considerable importance to prohibit a habit not uncommon among children of standing heavily upon one leg. The persistence in this habit, particularly in debilitated children is very apt to interfere with the perpendicular position of the spine, and lead to permanent curvature.

II. DEBILITIES.

Under the head of *Debilities of the Trunk* I include :—

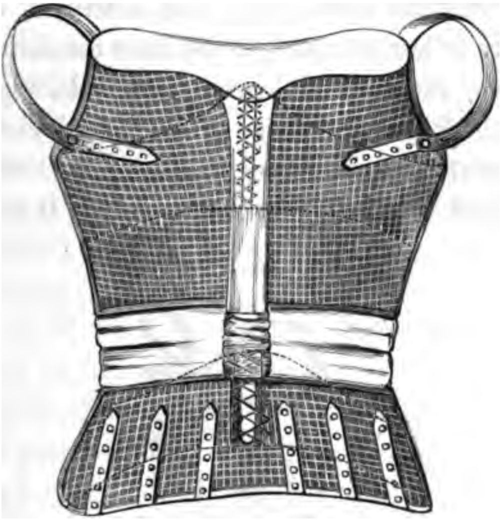
1. SPINAL DEBILITY.
    (*a.*) *Gymnastics of the Spine.*
2. RUPTURE.
3. PENDULOUS ABDOMEN.
4. PROLAPSE OF THE WOMB.
5. PROLAPSE OF THE RECTUM.

1. *Spinal Debility.*—Spinal debility is a vague term. It has been objected to, on the one hand, as including too much, on the other, as conveying too little—too much, as under one and the same term were concealed several different and disconnected pathological conditions ; too little, as it did not specify either the form of the debility or the special structures or structure affected by it. It is a term indeed, expressing our ignorance rather than our knowledge. But be this as it may, we cannot do very well without the designation. It is very useful and includes a large class of cases, which, until pathologists furnish us with a better terminology for them, are best described by the general expression, *spinal debility*. Among these cases are those numerous instances of incipient deflection of the spinal column which seem to arise from general debility of the whole system, and in which the different tissues of the spine and the attached muscles are equally affected. These cases are chiefly observed among young children, particularly those of weakly constitutions and who grow rapidly. In many, if not the majority, mechanical support alone, or in conjunction with regulated muscular exercise, is of great assistance

to the physician, and is frequently essential to the successful treatment of the case.

If the debility should have led to any of the more definite forms of curvature already discussed, the instruments described will be found available for the treatment; and more or less modified, they are adapted to control or relieve incipient curvatures. But special provision has also been made for the relief of general weakness of the spinal column, particularly when accompanied with a tendency to lateral curvature. The instrument (Fig. 124) designed for this purpose was invented by Dr. Abbe, of Boston, U.S., and was termed by him the Ortho-spinalis, or, in plain English, the spine-straightener. It consists of a light metallic frame, accurately representing the posterior surface of the thorax, and having at its centre, coincident with that point where the lumbar and dorsal curves generally blend, a free joint. On either side of this central joint bands of india rubber are fixed, which by their reaction against each other, serve to keep the apparatus in a perpendicular position. This instrument takes its principal bearing around the pelvis, and as its shape resembles that of a perfectly formed body, all trace of curvature is

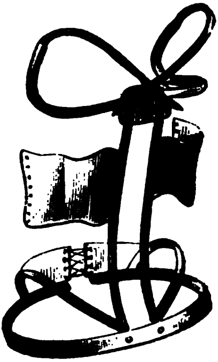
Fig. 124.



hidden, and in lieu a perfectly symmetrical trunk is presented. It is an extremely clever invention; and for supporting a weakened spine or preventing lateral curvature, acts better than anything else I am acquainted with.

Not unfrequently in conjunction with the signs of spinal debility, tenderness on pressure is found at some point of the spine. When this is the case it is necessary to adopt a form of instrument which, while affording support to the trunk and removing the weight of the head and shoulders, leaves the spinal column free from pressure. Instruments have already been described, which, more or less modified, would meet the difficulties of the case supposed (see, for example, Fig. 76). In the following drawing (Fig. 125) is depicted an apparatus specially designed to support the spine without exercising pressure upon it. It consists of a pelvic belt with hip bands, supporting two parallel vertebral levers, which, when the instrument is in position, rest upon either side of the spine without touching it. To the summits of the levers is attached a shoulder pad and arm rests, while to the middle is fastened an abdominal belt. A belt also passes from one hip band to the other across the hypogastrium.

FIG. 125.



Gymnastics of the Spine.

Gymnastics constitute one of the most important means we possess for remedying spinal debility and distortion. Within the past thirty years several attempts have been made to reduce those muscular exercises to a system, which have been found most beneficial for the treatment of deformities. Foremost among the workers who have sought this end must be named Ling, Roth, Georgii, Chiosso, and Heine. In many cases of slight or incipient spinal debility or deformity, gymnastics alone will prove sufficient to rectify the evil; but, as a rule, they are found most beneficial when used in combination with mechanical support.

Gymnastics have been much more extensively used for therapeutical purposes on the continent than in this country. Several years ago, I visited the most celebrated orthopædic establishments of Vienna, Dresden, Berlin, Stutgard, Caansdat, Munich, Paris, Brussels, &c., in which gymnastics were specially employed for the treatment of deformities. I found that almost without exception the successes obtained in these establishments arose from a judicious combination of gymnastics with mechanical support. The gymnastic appliances made use of were of the simplest order, consisting of a horizontal hand-swing, an inclined ladder, a few parallel bars, and some knotted ropes depending from the ceiling. With these slight aids almost every variety of gymnastic movement was performed.

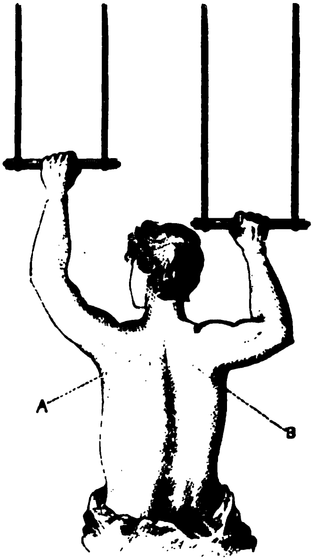
It is no part of my purpose to enter into a detailed description of one or other of the elaborate systems of gymnastics which have been suggested for the treatment of spinal deformities. These systems, as a rule, require the constant presence of the master for their effectual practice. I would refer to the special works which have been written on the subject.

My present object is to explain the nature and construction of such gymnastic appliances as have been found most useful as adjuncts to the treatment of spinal distortions, and to illustrate their ordinary uses.

Among the simplest may be mentioned the horizontal hand swing, which is constructed as follows: Two ropes of equal length, firmly secured to the ceiling of a room, carry at their lower extremities a polished wooden horizontal rod, sufficiently thick to be grasped firmly by the hands of the patient when standing on tiptoe. This form of apparatus is intended to exercise the muscles of the spine and chest, and its value arises from the necessary employment of a considerable amount of muscular power in swinging the body backwards and forwards, whilst suspended by the hands. When, however, spinal curvature has assumed a permanent character, the single horizontal bar seldom accomplishes any satisfactory result. For this class of cases I have devised a modification of the hand-swing, so constructed as to induce an expansion of the arcs of spinal curvature, whilst those muscles which exist within the concavities are more powerfully exercised than their stronger antagonists. By this arrangement, the muscles previously debilitated, are chiefly brought into play; and the objection frequently urged against gymnastic treatment in spinal deformity, namely, that it brings into operation those muscles which are already acting too strongly, is, to a great extent, set aside. To accomplish this end, two horizontal rods are required, arranged as represented in the following drawing (Fig. 126).

When the patient begins to swing the body, the arm on the concave side of the deformity is raised beyond the level of the opposite hand,

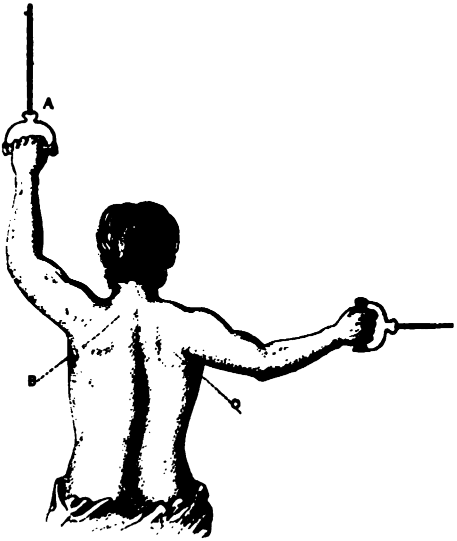
FIG. 126.



and thus produces a considerable amount of activity in those muscles (A) which act within the concavity of the curve; whilst, owing to the flexed and almost rigid position of the depressed hand (C), those muscles (B) situated on the convexity of the curve are left almost entirely at rest. By sedulously maintaining this system of exercise, in conjunction with mechanical support, vertical equilibrium may be gradually restored, whilst the health of the patient is invariably improved. This kind of swing is employed in cases of ordinary permanent curvature; but where an aggravated amount of distortion exists, it is customary to advise the use of an appliance (Fig. 127) which consists of two wooden handles fixed to powerful india-rubber cords. One of these cords acts in a vertical, the other a horizontal direction; the reason for this being, that the hand (A) corresponding with the concavity of the dorsal curve (B) should be raised, whilst that which corresponds to the convexity (C) should be laterally extended. By this means the attenuated muscles situated within the concavity of the dorsal curve are exercised without danger of opposition from their stronger antagonists.

When the left hand is drawn downwards it brings into action the muscles belonging to the dorsal concavity, while, as the right hand firmly grasps the horizontal elastic cord, those muscles situated upon the convexity are held in a comparatively quiescent state. If the left hand were not raised, holding the right one horizontally would increase the action of the muscles on the convexity of the upper curve; but owing to the oblique position given to the shoulders these muscles remain at rest.

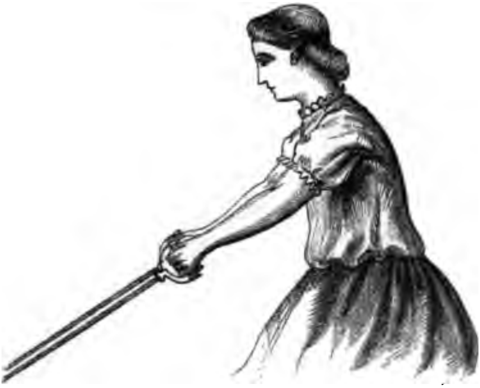
FIG. 127.



In cases of double lateral curvature, accompanied with debility in the erectors of the spine, the appliance generally employed is in the form of two strong elastic cords secured to the floor, and carrying handles so arranged that the patient has to stoop forward to reach them. On raising the body, the longissimus dorsi and sacro-lumbalis muscles are powerfully exercised, which is the object sought.

This movement being somewhat similar to

Fig. 128.



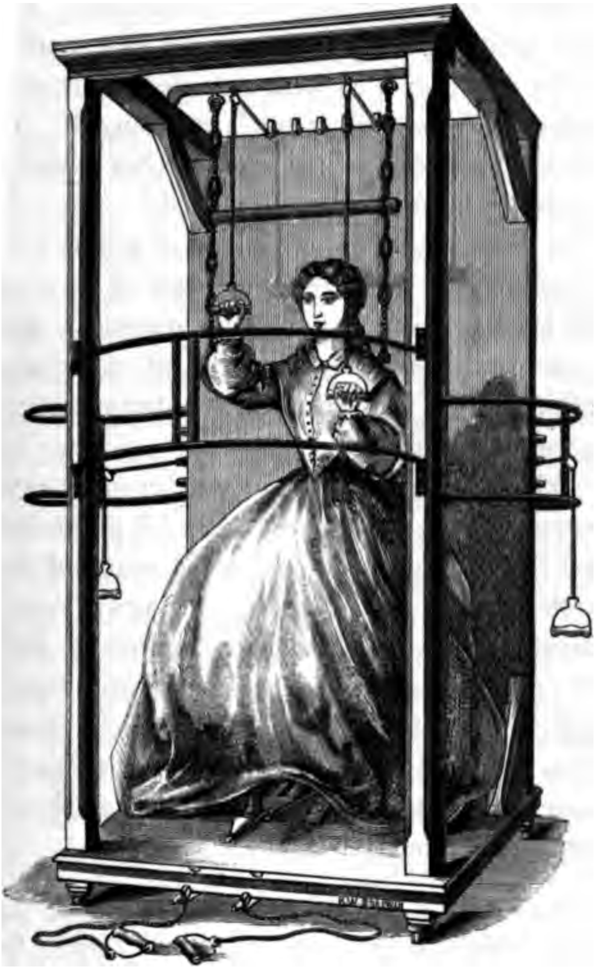
that employed by the upper workman in using the great double-handled saw, has received the inelegant designation of "the top-sawyer exercise."

The foregoing appliances are more or less valuable according to the cases for which they are employed; but, unless used with a certain amount of judgment and care, there is some risk of their accidentally increasing the curvature, by unduly exercising muscles already acting too forcibly.

To guard against the chance of this occurrence, I have contrived a portable gymnasium, so arranged that neither the patient nor physician can well err. An additional advantage is, that whilst the same apparatus is applicable for every variety of spinal distortion, it is also available as a gymnasium in which those members of a family who have no need of exercising their muscles for the relief of a deformity can yet improve their health, symmetry, and strength, by amusing themselves with the endless but simple exercises for which it is adapted.

The "gymnasium" (Fig. 129) consists of a square wooden frame, having a double back within which the weights and pulleys which govern the action of the respective cords are concealed, thus adding to the elegance of the structure, and preserving the apparatus from accidental derangement. Within the centre of this frame is a seat capable of being raised or lowered to suit the patient's height, and with its surface so inclined that the body simply rests against it in a semi-erect posture and can be fixed by a strap passing around the hips. Extending from the two front pillars are three double arches of metal, one at each side, and a third in the front. These arches give attachment, by means of loose pullies, to cords, which communicate with other pulleys hid in the back of the apparatus. Connected with these cords are handles. Over the head a cross-bar affords

FIG. 129.



attachment to other pulleys and handles, also to a trapeze, and, when needed, a chin-strap. Besides these appurtenances there are two handles at the feet connected with weighted cords and pulleys, also two pedals similarly arranged. To the weighted cords of the lateral arches webbing bands can be attached when needed.

In this arrangement of pulleys, it will be perceived that the patient has the power of drawing the handles towards her in all directions, and consequently has every variety of movement within grasp. The drawing shows the apparatus in use as an ordinary gymnasium.*

When planning this gymnasium, in so far as it is applicable to spinal curvature, I felt persuaded that the body must be fixed in the centre of the mechanism. I also judged that the arcs of spinal curvature must be expanded concurrently with the muscles placed within their concavities being brought into action, and that the whole spinal column should be slightly extended, so as to remove the vertical weight of the head and shoulders from the intervertebral cartilages.

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* This form of gymnasium has been adopted for use at the National Hospital for Paralysis and Epilepsy, by Dr. Radcliffe.

To accomplish the first requisition, the apparatus is made to receive the patient in its centre in a half-erect posture, that is to say, neither sitting nor standing; but with the pelvis resting against an inclined seat, and fixed to it by a padded band, which thus secures firmness of resistance in anticipation of the exercises about to be taken.

To carry out the second idea, I have arranged the webbing bands referred to, so that one may press upon the arc of the dorsal, and the other upon the arc of the lumbar curve, the bands being fixed to opposite sides of the mechanism, and weighted in proportion to the resistance offered by the several curves. By this arrangement the patient moves and breathes freely, notwithstanding that the spinal arcs are compressed at their centres, and expanded at their extremities by the weighted elastic bands. Lastly, the head of the patient is secured in a little padded chin-strap, fixed by an elastic band to the upper part of the apparatus; the effect of which is to entirely remove the weight of the head from the intervertebral substances, and thus aid the lateral webbing bands in expanding the arcs of curvature. Thus fixed in the centre of the mechanism, the body preserves a perfect degree of equilibrium, and is brought as nearly as possible to a straight line, which in a distorted figure is one of the first points to be arrived at.

By acting against the natural tendency of a deformed spine to increase its arcs of curvature, the muscles on the convexities of the curves become relaxed, and their resistance to their weaker antagonists is diminished. And by extending the spine between the occiput and pelvis, as effected by the chin-strap, a certain amount of tension upon the debilitated muscles situated within the concavities of the curves is brought about and their contractility called into action.

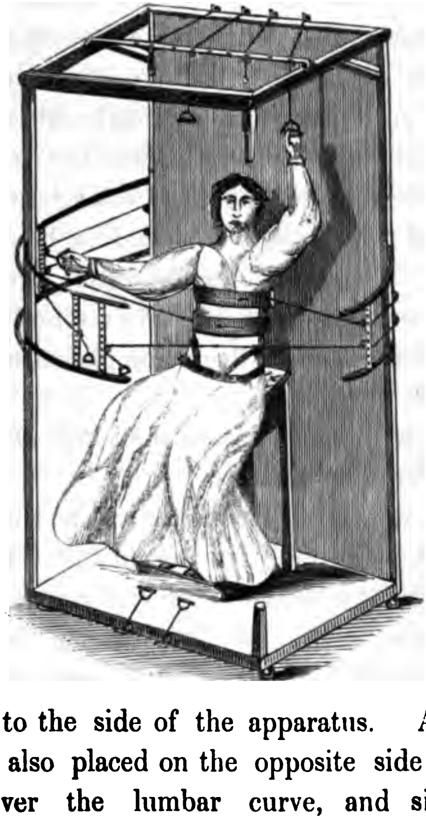
These points are entirely novel in the treatment of spinal curvature by gymnastic exercises.

An important feature of this arrangement is, that as the webbing bands are always acted upon by weights, the movements of the arms and hands tend to unfold the spinal arcs of curvature, whilst the necessary exercise for strengthening the muscles remains unimpeded.

The following drawing (Fig. 130) represents one of the most useful exercises in cases of double lateral curvature—viz., one arm upraised and the other extended.

It will be seen that the patient's pelvis is fixed a strap to the seat; whilst over the arc of dorsal curve, and acting in a direction calcued to diminish it, a band passes which is at-

Fig. 130.



hed to the side of the apparatus. Another d is also placed on the opposite side of the ly over the lumbar curve, and similarly fastened to the side. Both bands are acted upon by weights carefully proportioned to the *degree* of curvature. The head rests in a padded band. The left hand is perceived to be raised for the purpose of pulling downwards a weight, and thus exercising the muscles on the concavity of the dorsal curve. The right hand is laterally extended, so that the muscles in the concavity of the lumbar curve may also be brought into action.

Whilst carefully investigating the method by which only those muscles which are actually required to be exercised should be brought into activity, I arranged the following tables as a guide for the adoption of such exercises as would particularly tend to the accomplishment of the object in view.

The *first table* refers to the action of the different vertebral muscles.

The *second table* shows the action of each vertebral muscle in relation to spinal curvature.

The *third table* shows the vertebral muscles as distributed in the different regions of the spine.

The *fourth table* classifies the muscles particularly implicated in maintaining the arcs of curvature.

When I first began to examine the various muscles of the spine, with a view to ascertain the influence which they severally exerted, I soon perceived that some system must be devised for finding their aggregate action; because unless this action could be determined with accuracy, very little good would result from the employment of exercises.

After thinking of several plans by which the action of the spinal muscles might be ascertained, I hit upon the following, as most easy of adoption. I fixed to an ordinary skeleton, pieces of tape, representing the position held by the different muscles. In order to distinguish the various anatomical layers, I used tape of six various colours. By this means, the action of the muscles in different combinations could be readily deduced.

Taking away one or more of the tapes representing muscles, I was enabled to calculate how the remainder would exercise their force.

By placing also the skeleton in a contorted form, I could estimate the probable result of the change upon particular muscles. Feeling the importance of any experiments of the kind, I prepared the tabulated forms which follow. They are not perfect, but such as they are, they will facilitate the employment of gymnastic exercises.

TABLE I.

The *levatores costarum* are attached to the last cervical, and to eleven dorsal vertebræ, and are inserted into the whole of the ribs between their angles and tubercles. The mechanical action of these muscles is that of raising the ribs, and for this purpose they act from the spine as a fixed point. Upon any disturbance of their mutual equilibrium they tend, by unduly approximating the ribs on the side of most action, to promote dorsal curvature.*

The *intertransversales* are attached to the transverse processes of the entire vertebræ. Their action is that of maintaining the spine erect. When equilibrium is disturbed, they favour a lateral curvature of the entire spinal column.

The *interspinales* are attached to the spinous processes of the cervical and lumbar vertebræ. They hold the spine erect, but, when disturbed, admit of the vertebræ flexing anteriorly.

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* By disturbance of equilibrium the author means to convey the idea that an interruption to the antagonism between the two sets of muscles has taken place.

The *multifidus spinæ* passes along the whole length of the spine in the groove formed by the transverse and spinous processes; it is also attached to the sacrum and ilium. Its action maintains the spine laterally erect. When disturbed, yielding ensues in a lateral direction.

These four muscles constitute the sixth layer, and give stability to the spinal column.

The *obliquus superior* passes from the atlas to the occiput. Its action tends to hold the head erect, and aids rotation. When disturbed, reverse action occurs.

The *obliquus inferior* extends from the transverse process of the atlas to the spinous process of axis, and aids oblique rotation.

The *rectus lateralis* joins the occiput to the atlas, and aids rocking of the head. Disturbed, reverse action occurs, as in cervical curvature.

The *rectus posticus minor* arises from the atlas, and joins the occiput; it holds the head backwards. Disturbed, reverse action occurs.

The *rectus posticus major* arises from the axis, and joins the occiput; it keeps the head posteriorly perpendicular, and also draws it backwards. When disturbed, reverse action occurs.

These five muscles move the head upon the spine.

The *semispinalis colli* runs from the transverse processes of fifth and sixth upper dorsal to the spinous processes of the four upper cervical vertebræ; it gives perpendicular motion to the cervical vertebræ, and, when disturbed, favours cervical curvature.

The *semispinalis dorsi* is attached to the transverse processes of from six to ten dorsal vertebræ, and is inserted into the transverse processes of the four upper dorsal and two cervical. It exercises perpendicular action against the dorsal vertebræ, and, when disturbed, it facilitates the creation of lateral cervico-dorsal curvature. The semispinalis dorsi and colli act as erectors of the neck.

The seven preceding muscles constitute the fifth layer.

The *complexus* is attached to the transverse processes of three upper dorsal and one lower cervical vertebræ, and is inserted into the curved line of the occiput. It serves to move the head backwards, and aids rotation.

The *trachelo-mastoideus* is attached to the three upper dorsal and last cervical vertebræ; it is inserted into the mastoid process. The muscle thus assists the rectus lateralis in lateral movement of the head, and also the semispinalis colli and splenius capitis, in acting laterally on cervical vertebræ in the creation of cervical curvature.

The *transversalis colli* is attached to the fifth and sixth upper dorsal, and inserted from the second to the sixth cervical vertebræ. Its action helps the intertransversales, and in cervical curvature it becomes contracted.

The *cervicalis ascendens* is attached to the angles of third, fourth, fifth, and the sixth ribs, and is inserted into the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ. Its action is to draw the ribs upwards or cervical vertebræ obliquely downwards, and thus, when disturbed, it serves to maintain cervical curvature.

The *spinalis dorsi* arises from the spinous processes of the two upper lumbar and two lower dorsal vertebræ, and is inserted into the spinous processes of the upper dorsal from the second to the eighth. It is an erector of the spine, and as such assists the interspinales, sacro-lumbalis, and longissimus dorsi. When disturbed, posterior curvature ensues.

The *sacro-lumbalis* arises from the sacrum, ilium, and lumbar vertebræ, and is inserted into the angles of the six lower ribs. Its action is to keep the lumbar vertebræ erect. When disturbed, it materially influences the formation and maintenance of lumbar curvature.

The *longissimus dorsi* arises from the sacrum and lumbar vertebræ, and is inserted into the angles of eleven ribs and the transverse processes of the dorsal and lumbar vertebræ. It contracts in conjunction with the sacro-lumbalis, and acting upon the lumbar and dorsal vertebræ erects the spine. When disturbed, it induces lumbar curvature.

These seven muscles constitute the fourth layer.

The *splenius colli*, and *splenius capitis.*—These two muscles have a common origin from the six upper dorsal spinous processes and last cervical. The former is inserted into the transverse processes of the three or four upper cervical vertebræ; the latter into the rough surface of the occiput, and the mastoid portion of the temporal bone. They act conjointly in holding the head erect, and rotating it.

The *serratus posticus inferior* is attached to the spinous processes of the two lower dorsal and two upper lumbar vertebræ, and is inserted into the angles of the four lower ribs. Its action is that of depressing the ribs, and also slightly aiding rotation of the ribs upon the vertebræ.

The *serratus posticus superior* is attached to the spinous processes of the two upper dorsal and one lower cervical vertebræ, and is inserted into the margins of the second, third, fourth, and fifth ribs. Its action is antagonistic to the preceding muscle, and tends to raise the ribs upon the spine. Disturbed, it creates dorso-lumbar curvature.

These four muscles constitute the third layer.

The *rhomboideus major* arises from the spinous processes of the four upper dorsal vertebræ, and is inserted into the posterior border of the scapula. Its action is that of drawing the scapula horizontally back to the spine, or the spine to scapula.

The *rhomboideus minor* arises from the spinous processes of the last cervical vertebræ, and is inserted into the edge of the triangular surface of posterior border. It draws the scapula obliquely upwards to the cervical vertebræ.

These two muscles particularly influence the convexity of dorsal curves.

The *Levator anguli scapulæ* arises from the transverse processes of the four upper cervical vertebræ, and is inserted into the upper angle and posterior border of the scapula. Its action is to draw the scapula upwards towards the cervical vertebræ, or the spine downwards to scapula.

The three preceding muscles form the second layer.

The *latissimus dorsi* arises from the spinous processes of the lower dorsal and all the lumbar vertebræ, also from the sacrum, ilium, and four lower ribs, and is inserted into the bicipital groove of the humerus. The action of this muscle tends to draw the shoulder back upon the spine, or the spine laterally to the shoulder. It also steadies the scapula by pressing upon its inferior angle.

The *trapezius* arises from the inner third of occiput, and is attached to the last cervical and the whole of the dorsal vertebræ, also to the scapula with clavicular attachment from occiput to clavicle. It exercises action upon the shoulder in three directions, viz., its clavicular and occipital fibres draw it upwards, its upper dorsal, cervical, and scapular fibres, backwards, its lower dorsal fibres, slightly downwards.

These two muscles form the first layer.

This table exhibits the mechanical action of each vertebral muscle; so as to show the mode of production of spinal curvature from want of muscular antagonism.

Mechanical Action.	Upwards.	Downwards.	Laterally.	Obliquely.	Backwards.
1st LAYER.					
Trapezius . . .	Scapula to occiput	Occiput to scapula	Scapula to vertebræ Vertebræ to scapula	Scapula to occiput. Scapula to vertebræ.	
Latissimus dorsi . .	—	—	Humerus to spine Spine to humerus	Humerus to spine. Spine to humerus.	
2nd LAYER.					
Levator anguli scapulæ .	Scapula to cervical vertebræ	Cervical vertebræ to scapula	—	Scapulæ to cervical vertebræ.	
Rhomboideus minor .	—	—	—	Cervical vertebræ to scapula.	
Rhomboideus major .	—	—	Scapula to cervico-dorsal vertebræ Cervico-dorsal vertebræ to scapula	Scapula to cervical vertebræ. Cervical vertebræ to scapula.	
3rd LAYER.					
Serratus posticus sup. .	Ribs upon spine.				
Serratus posticus inf. .	—	Ribs upon spine.			
Splenius capitis . .	—	—	—	Mastoid process to vertebræ	Head to vertebræ.
Splenius colli . .	—	—	—	—	Cervical vertebræ.

TABLE II (*continued*).

Mechanical Action.	Upwards.	Downwards.	Laterally.	Obliquely.	Backwards.
4TH LAYER.					
Longissimus dorsi .	—	—	—	Lumbar and dorsal vertebræ upon pelvis	Vertebræ upon pelvis.
Sacro lumbalis .	—	Ribs upon vertebræ	—	Lumbar vertebræ upon pelvis	Vertebræ upon pelvis.
Spinalis dorsi .	—	—	—	—	Vertebræ upon pelvis.
Cervicalis ascendens .	Ribs upon cervical vertebræ	Cervical vertebræ on ribs	—	Cervical vertebræ to ribs.	
Transversalis colli .	—	—	—	Cervical upon dorsal vertebræ	Cervical upon dorsal vertebræ.
Trachelo mastoideus .	—	Head to vertebræ	—	Head on cervical vertebræ. Cervical vertebræ on head.	
Complexus .	—	—	—	—	Head upon vertebræ.
5TH LAYER.					
Semi-spinalis dorsi .	—	—	—	—	Cervical upon dorsal vertebræ.
Semi-spinalis colli .	—	—	—	—	Cervical upon dorsal vertebræ.
Rectus posticus major .	—	—	—	—	Occiput upon cervical vertebræ.
Rectus posticus minor .	—	—	—	—	Occiput upon cervical vertebræ.
Rectus lateralis .	—	Head upon spine	Head upon spine	Head upon spine.	
Obliquus inferior .	—	—	—	Head upon spine.	
Obliquus superior .	—	—	—	Head upon spine.	
6TH LAYER.					
Multifidus spinæ .	—	—	The whole vertebræ.	—	The whole vertebræ.
Interspinales .	—	—	—		
Intertransversales .	—	—	The whole vertebræ.		
Levatores costarum .	The ribs upon the vertebræ	—	—	Ribs upon vertebræ.	

TABLE III.

This table specifies, according to their anatomical layers, those muscles, and their mechanical actions, which are found grouped together in the cervical, dorsal, and lumbar regions, and thus enables the reader to ascertain the special influence they combinedly exercise in the production and retention of lateral curvature.

Cervical Region.

The *trapezius*, draws the cervical vertebræ towards the shoulder, and the shoulder towards the vertebræ.

The *levator anguli scapulæ*, lifts the scapula towards the head, and draws the head downwards.

The *rhomboideus minor*, draws the scapula in an oblique direction to the spine, or the spine to the scapula.

The *serratus posticus superior*, lifts the ribs upwards upon the spine, and the spine to the ribs.

The *splenius capitis*, draws the head obliquely to the spine.

The *splenius colli,* draws the cervical vertebræ laterally.

The *cervicalis ascendens,* raises the ribs upon the cervical vertebræ, or draws the cervical vertebræ obliquely downwards.

The *transversalis colli,* helps in sustaining the head and neck erect.

The *trachelo mastoideus,* moves the head laterally, and draws the cervical vertebræ towards the head.

The *complexus,* draws the head backwards, and holds the neck erect.

The *semispinalis dorsi,* exercises slight perpendicular traction against the cervical vertebræ.

The *semispinalis colli,* exercises perpendicular traction against the cervical vertebræ in a larger degree.

The *multifidus spinæ,* holds the head and neck laterally erect.

The *interspinales,* hold the head and neck posteriorly erect.

The *intertransversales,* maintain the vertebræ in an erect position.

The *levatores costarum,* raise the ribs upon the cervical vertebræ.

Dorsal Region.

The *trapezius,* draws the scapula almost horizontally to spine, and spine to scapula.

The *latissimus dorsi,* draws the shoulder towards the dorsal vertebræ, and spine to shoulder.

The *rhomboideus major,* draws the scapula horizontally to vertebræ, and the vertebræ to the scapula.

The *serratus posticus superior,* lifts the ribs upon the spine.

The *serratus posticus inferior,* depresses the ribs upon the spine.

The *splenius capitis,* draws the head towards the dorsal vertebræ, and dorsal vertebræ to the head.

The *longissimus dorsi,* creates oblique action in the whole dorsal vertebræ.

The *spinalis dorsi,* holds the spine perpendicularly erect posteriorly.

The *tranversalis cervicis,* maintains the dorsal and cervical vertebræ mutually erect.

The *trachelo mastoideus,* obliquely flexes the cervical vertebræ.

The *complexus,* draws the head backwards and holds it erect.

The *semispinalis dorsi*, gives perpendicular attachment to the dorsal vertebræ.

The *semispinalis colli*, helps to keep the cervical and dorsal vertebræ erect.

The *levatores costarum*, lift the ribs upon vertebræ.

Lumbar Region.

The *latissimus dorsi*, draws the shoulder towards the lumbar vertebræ, and the spine to the shoulder.

The *serratus posticus inferior*, depresses the ribs upon the spine.

The *sacro-lumbalis*, exercises perpendicular action on the whole of the lumbar vertebræ.

The *longissimus dorsi*, creates oblique action on the whole of the lumbar vertebræ.

The *spinalis dorsi*, hold the lumbar vertebræ posteriorly erect.

The *interspinales*, hold the lumbar vertebræ posteriorly erect.

The *multifidus spinæ*, holds the spine laterally erect, and by relaxation induces slight lateral action.

The *intertransversales,* hold the lumbar vertebræ laterally.

Costal Region.

The *latissimus dorsi,* being affixed to the ribs, tends to draw the dorsal vertebræ into oblique lateral action.

The *sacro-lumbalis,* holds the spine erect, and exercises oblique lateral action against lumbar vertebræ.

The *cervicalis ascendens,* lifts the ribs upon the spine, and draws the cervical vertebræ obliquely downwards.

The *serratus posticus superior,* lifts the ribs upon the spine, or draws the spine to them.

The *serratus posticus inferior,* depresses the ribs upon the spine, or draws the vertebræ to them.

The *longissimus dorsi,* holds the lumbar vertebræ erect, or draws the ribs downwards upon them.

The *levatores costarum,* raise ribs upon vertebræ.

Scapular Regions.

The *trapezius*, draws the scapula upwards, backwards, and slightly downwards.

The *levator anguli scapulæ*, raises the scapula towards cervical vertebræ, or draws the spine downwards to scapula.

The *rhomboideus minor*, draws the scapula towards the dorsal vertebræ, and the spine to scapula.

The *rhomboideus major*, draws the scapula horizontally to the dorsal vertebræ and the spine to scapula.

Pelvic Region.

The *latissimus dorsi*, draws the whole of the dorsal and lumbar vertebræ, together with the ribs, in an oblique direction downwards.

The *sacro lumbalis*, acting from the pelvis as a fixed point, induces indirect lateral movement of the lumbar vertebræ.

The *longissimus dorsi*, produces indirect lateral action in both lumbar and dorsal vertebræ.

The *multifidus spinæ*, holds the spine erect.

This table is intended to classify those muscles which are particularly implicated in maintaining the arcs of spinal curvature, and to explain how, by their conjoined mechanical action, they primarily induce deformity.

		REGION.	CERVICAL.		DORSAL.		LUMBAR.	
		On the side of muscular contraction is created .	Convexity.	Concavity.	Convexity.	Concavity.	Convexity.	Concavity.
Mechanical Action.	Laterally.	Direct . .	Rhomboideus minor. Trapezius (middle fibres).		Rhomboideus major. Trapezius (middle and lower fibres).		Latissimus dorsi.	
		Oblique . .	Semi-spinalis colli. Cervicalis ascendens. Serratus posticus superior. Trapezius (upper fibres).	Splenius capitis. Levator anguli scapulæ. Trachelo mastoideus.	Complexus. Trachelo mastoideus. Longissimus dorsi. Sacro lumbalis. Splenius capitis.	Semi-spinalis dorsi. Transversalis cervicis. Serratus posticus superior.	Serratus posticus inferior. Latissimus dorsi.	
		Indirect . .		Inter-transversales. Multifidus spinæ. Complexus. Transversalis colli. Splenius colli.	Semi-spinalis colli. Serratus posticus inferior.	Inter-transversales. Latissimus dorsi. Multifidus spinæ.		Inter-transversales. Multifidus spinæ. Longissimus dorsi. Sacro-lumbalis.
	Posteriorly . . .				Interspinales. Spinalis dorsi.		Interspinales. Spinalis dorsi.	

2. Rupture.

Rupture (*hernia*) is a protrusion of the intestines beyond the normal limits of the abdominal cavity. Certain parts of the abdominal walls are less strong than others. These are apt to yield to the pressure of the bowels from within outwards. The containing walls bulge, and a pouch is formed, into which a fold of intestine escapes. This frequently occurs suddenly, hence the term *rupture* as signifying a breaking through of the abdominal wall.

The parts of the abdomen where rupture is most apt to occur are the groin, where the spermatic blood-vessels escape from the cavity; the hollow of the thigh, where the blood-vessels supplying the lower extremities leave the abdomen, the navel, and certain less definitely circumscribed portions of the anterior wall. When a rupture occurs in the groin it is known as *inguinal;* when in the hollow of the thigh, as *femoral;* when at the navel, as *umbilical;* and when at any other portion of the anterior abdominal wall, as *ventral.*

Other forms of rupture also occur. The bowel may force a way between the bladder and rectum, forming a tumour in the perinæum (*perineal rupture*); or it may descend into the vagina (*vaginal rupture*); or it may find a way into the pudendum (*labial* or *pudendal rupture*); or it may obtain a passage through the obturator ligament (*obturator* or *thyroid rupture*); or sciatic notch (*ischiatic rupture*). Finally, a fold of bowel is sometimes forced through the diaphragm (*diaphragmatic rupture*).

Rupture is a serious drawback to the physical efficiency of an individual. At any moment the protruded bowel may become strangulated, and imminent danger to life occur. To obviate this danger, as well as to place the ruptured wall of the abdomen in the most favorable condition for a recovery of its resisting powers to intestinal pressure, mechanical aid is needed; an artificial support must be substituted for the defective resistance of the abdominal wall; and the construction of such a support is a question coming strictly within the province of the orthopractic mechanician.

In devising an instrument for restraining a rupture, the mechanician has to consider the direction of the protrusion, its bulk (which may vary from the size of a walnut to that of a child's head), and the magnitude and form of the aperture through which the protruded bowel passes. The pressure is sometimes complicated by the existence of more than one rupture in the same individual. I have had to contend with a case in which the patient suffered from right inguinal, left femoral, an umbilical and a ventral rupture at the same time. The late Louis Philippe had double inguinal and an umbilical rupture at the period of his decease.

The various instruments which have been designed to meet the foregoing requirements have been termed *trusses*. To *truss* is to bind or pack close; to skewer or to make fast. To *truss up* is to make close or tight. And so *a truss* is the means of binding or making close or tight.

I shall now describe the different trusses which have been invented for the treatment of the various forms of rupture, touching only so far upon surgical and anatomical details as will be absolutely necessary to show the construction of the instruments and their mode of application. The following arrangement will be adopted :—

A. INGUINAL RUPTURE.
  (*a*) *Scrotal Rupture.*
  (*b*) *Congenital Rupture.*
B. FEMORAL RUPTURE.
C. UMBILICAL RUPTURE.
D. VENTRAL RUPTURE.
E. VAGINAL RUPTURE.
F. RECTAL AND PERINÆAL RUPTURE.
G. PUDENDAL RUPTURE.
H. OBTURATOR RUPTURE.
I. ISCHIATIC RUPTURE.

Diaphragmatic rupture is beyond the reach of mechanical aid.

A. *Inguinal rupture.*—This variety of rupture varies in size from a small nut to a hen's egg. It may occur on one side only or on both sides. It may be *direct* or *oblique*. It is called direct when the bowel is forced directly from the abdomen through the external abdominal ring; *oblique*, when, entering the external ring, it passes down the inguinal canal, and so appears at and passes through the external ring. When the rupture does not project through the external ring, but occupies the inguinal canal, it is known as a *bubonocele*.

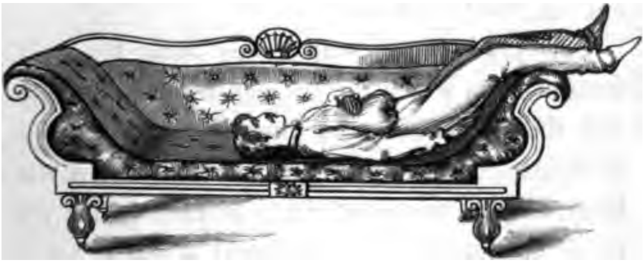
The course of a *direct* inguinal rupture is in a straight line from before forwards; of an *oblique* inguinal rupture, first, with an inclination downwards towards the middle line of the body, following the direction of the inguinal canal, then outwards through the external abdominal ring, finally downwards towards the scrotum.

In reducing a rupture by the taxis pressure must be applied in the opposite direction to that taken by the bowel; and a truss approaches perfection most nearly when it is so constructed as to keep up a permanent pressure in the line or lines of action adopted in using the taxis.

In applying the taxis a more accurate knowledge of the mechanical requirements of the case will be obtained if the patient can be kept erect, and the bowel be returned while he is in this position. This, however, is only practicable, as a rule, when the rupture is of old standing, and the hernial ring very large. When any difficulty is experienced it is requisite that the patient should be placed upon his back and the legs flexed, the thigh on the side of the rupture being, moreover, brought slightly towards the opposite thigh. In this position the tissues beneath which the protruding bowel passes are relaxed.

For twenty years I have found great advantage from using a sofa, which I have had specially constructed to facilitate the application of the taxis. The ends are so arranged that the patient being laid upon his back with the legs placed over one extremity, he is in a position best suited for the reduction of the rupture, and less irksome to himself than if the legs were supported by the hand. The following drawing (Fig. 131) represents the sofa and position of the patient.

Fig. 131.



When a rupture is small the simplest mechanical arrangement often suffices to restrain the further protrusion of the bowel. But the difficulty of control increases in direct proportion to the bulk of the rupture.

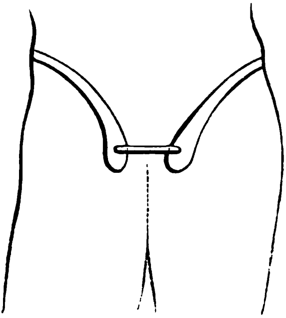
The earliest truss constructed for inguinal hernia was a broad band of leather or other material, which passed around the pelvis and secured a thick pad above the aperture through which the bowel protruded. An attempt has been made to revive this form of truss. It may have proved efficacious in relieving any small direct ruptures and bubonoceles, but it is an exceedingly untrustworthy arrangement. It is impossible to fix the pad so as to secure that degree of pressure upon the aperture of protrusion, in all positions of the patient's body, which is necessary fully to restrain the rupture. It is a dangerous instrument, giving the appearance without the reality of relief.

This crude arrangement was long the only form of truss which the surgeon could command, and the first attempt to improve upon its construction consisted in the substitution of a metal hoop, hinged, or so soft as to be flexible, for the pelvic bandage. No mechanical advantage was gained by this change, while the instrument was made more cumbersome and less easy to be worn.

The next and crowning advance in the fabrication of trusses was the use of a steel spring in place of the metal hoop.

So early as 1665 Matthias Major recommended elastic bandages of steel. But the introduction of steel-spring trusses into the surgical practice of this country is due to Timothy Sheldrake, who first published a description of his plan in 1784. Sheldrake's claim to priority of invention has, however, been very severely contested. The following drawing (Fig. 132) of Sheldrake's truss is copied from his work '*Observations on the Treatment of Ruptures, and the Description of an Improved Elastic Truss,*' 1784. It will be seen to represent faithfully the common trusses now in use.

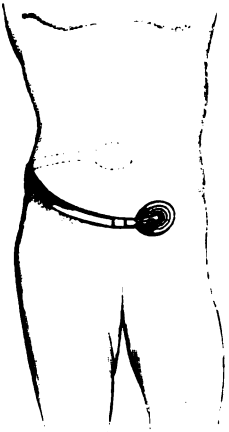
FIG. 132.



From the time of Sheldrake and the adoption of the steel spring, the varieties in the construction of trusses have been almost innumerable. By the spring a firm and equable pressure of the pad of the truss upon the aperture of protrusion of the bowel could be in a great measure secured. But in the adaptation of the spring to its peculiar purpose an immense field was opened to the exercise of ingenuity. Almost every surgical instrument maker of repute during the last fifty years has introduced some modification in the form of the spring or the construction of the pad. To describe the series of modifications would be as wearisome as uninstructive. Attention will be given solely to those forms of trusses which have best stood the test of practice or which are most popular.

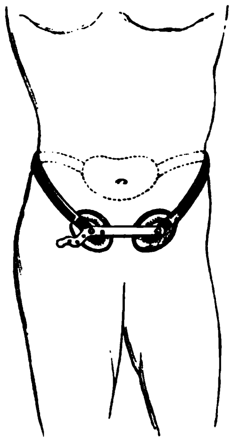
Foremost amongst these, after Sheldrake's truss, is one invented by Messrs. Salmon and Ody. The peculiarities of this truss are as follows:—(1) The spring extends from the centre of the spine across the abdomen to the hernial ring —the truss being so arranged that it passes round the opposite half of the body to that on which the rupture occurs (Fig. 133). (2) The pad is attached to a ball-and-socket joint, so that it may more accurately follow the motions of the trunk. This is an admirable form of truss, and is still deservedly held in high estimation. The double truss made by this firm is shown in Fig. 134.

FIG. 133.



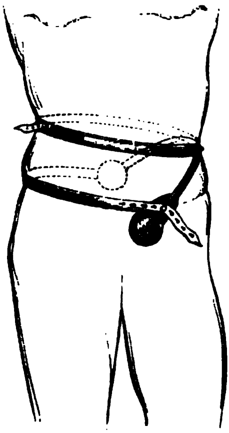
Another variety of truss which has obtained wide popularity was invented by Mr. Coles (Fig. 135). This truss was highly lauded by Mr. Cobbett, the economist, who suffered from inguinal hernia. The spring differs little in form from that of Salmon and Ody, but it is applied to the side of the body on which the rupture occurs. The speciality of construction is in the pad, and upon this depends the patent right of the instrument. It is pear-shaped, and contains within it a flat, helical spring, which performs the same function as the ball-and-socket joint, but retains the pad more accurately fixed against the hernial ring. This is an excellent light truss in ordinary cases. But both Coles', and Salmon and Ody's truss are objectionable in so far as, from the action of the helical spring and the ball-and-socket joint, the pad tends to bury itself in the wall of the abdomen and so enlarge the aperture of protrusion of the rupture.

FIG. 134.



A truss invented and patented some years ago by Dr. Tod is constructed upon a different principle. An attempt has recently been made by a London mechanist to revive the principle of fabrication of this truss, apparently in ignorance that it was already the subject of a patent right. Dr. Tod's truss (Fig. 136) consists of a spring which

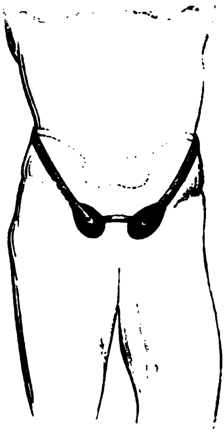
FIG. 135.



passes *over* the crest of the ilium, and not below it across the gluteal muscles. He also adopted a small pad, and his notion was that by the position of the spring a more direct control was obtained over the internal abdominal ring. It is doubtful whether any advantage is gained from this arrangement, but the conception was certainly ingenious.

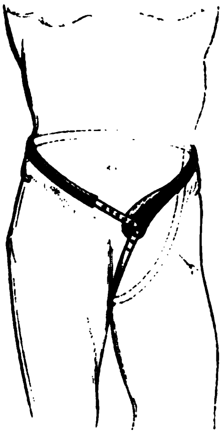
A truss which has been more recently constructed on Dr. Tod's principle, differs only in the kind of pad—this being large and oval in shape instead of small and pyriform.

FIG. 136.



When first I began to devote attention to the subject of rupture, I observed that in the act of reducing an inguinal hernia the direction taken by the hand was always upwards and inwards. It seemed to me that this fact should be the guide to the construction of an inguinal truss. The now common truss spring, which encircles the pelvis, secured the inward pressure needed. Accordingly I adopted this form of spring. But a modification of the pad was required, in order to obtain that upward pressure which was to be desired. This end I obtained by acting upon the pad by a convolute spring, like the fusee of a watch, placed within it. The difference in the arrangement of the pad of this truss and of that made by Coles is this:—In the latter the axis of the spiral spring is in a direct line from before backwards; in the former the axis is oblique and is fixed in the direction of the axis of the inguinal canal. By this modification the lower edge of the pad is tilted slightly up so as effectually to close the lower segment of the hernial ring, and prevent the rupture descending beneath the

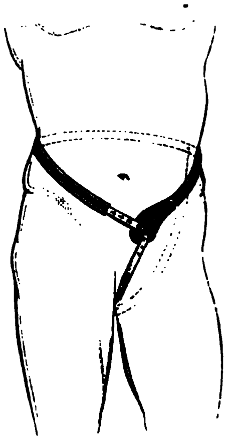
FIG. 137.



truss. The truss, which I have termed the *convolute spring truss* (Fig. 137), answered its purpose well, and is still in use.

Sometimes a hernia is so difficult to retain within the abdominal cavity that the object can be secured only by pressure admitting of careful regulation. To meet this obstacle a ratchet-wheel has been adapted to the pad of the truss, by means of which, when acted upon by a key, the pressure of the pad can be increased to any extent. In the accompanying diagram of a ratchet truss, a button fixed in the centre of the pad acts upon the mechanism (Fig. 138).

Fig. 138.



Dr. Arnott suggested a means of securing the same object by the aid of a chain passing along the spring. This chain could be tightened by a key, so as to increase the pressure of the spring at will.

But cases of inguinal rupture are at times met with which cannot be controlled by any of the previously described trusses. I have endeavoured to overcome the extreme difficulties occasionally found in these cases by the construction of a triple-lever truss, by means of which three different lines of force are brought to bear on the hernial ring. The following drawing will best explain this kind of apparatus.

A, B, C, Are three springs of different lengths, moving freely by means of small staples on the margins of the triangular pad.

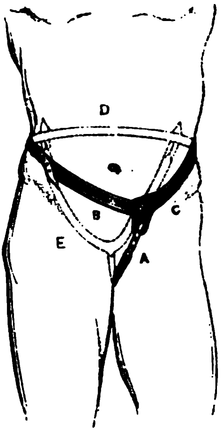
D Is a soft padded leather or silk band passing around the pelvis, and containing within it the three springs.

E Is a silk strap fixed to the lower spring A.

A small button placed in the centre of the pad acts upon the springs, and on being turned increases or diminishes the pressure upon the hernial ring.

Owing to the various lengths and positions of

Fig. 139.



the springs, each acts in a different direction upon the rupture—A tilts the lower edge of the pad upwards; B acts equally upon the whole surface of the pad, pressing it inwards and upwards; while C acts upon the centre of the pad, forcing it directly inwards. By the combined action of the three springs the tendency of a severe rupture to slip beneath the pad is effectually controlled. For by the upwards and inwards action given to the truss, the lower segment of the hernial ring is more effectually guarded, and there is less chance of displacement of the instrument.

Although the steel pelvic spring has become the grand characteristic of the trusses in common use, certain forms of bandages have been invented in which the office of the pelvic spring has been sought to be obtained by elastic material or otherwise.

A well-known instrument belonging to this class is the *moc-main truss.* It is formed of a padded leather pelvic band and a large oval pad. The pad is stuffed with floss silk, in the midst of which a small metal lever is placed. A thigh strap is attached by one extremity to this lever, and controls its action when the truss is in use. This instrument has been largely adopted in slight cases, and it is sometimes of value, as a relief from the less flexible trusses, when it is necessary to control a rupture in the night as well as the day.

An attempt has been made to substitute vulcanized india-rubber for the metal lever in an arrangement similar to the moc-main truss, but the result has not been such as to induce confidence in the arrangement.

An elastic bandage with air-pad is sometimes made use of as an inguinal truss. The bandage is constructed of strips of india-rubber fabric joined together in a spiral form. A distended air-pad is fixed above the hernial ring. This arrangement is found to be very untrustworthy except only in such cases where a very slight amount of pressure suffices to retain the rupture.

No doubt can be entertained that an inguinal hernia is most securely restrained, and the patient less inconvenienced, by a pelvic spring truss than by any other form of bandage.

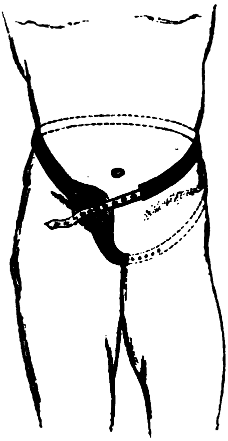
It is necessary, however, if the patient is to derive the fullest benefit from the truss, that it be accurately fitted to him. If the spring be not made to fit the individual it must act imperfectly. Much mischief results from the sale of ready-made trusses. Trusses are not like clothes, in which nicety of fit is not a matter of essential importance. The utmost injury that the ready-made clothes dealer can inflict upon his fellow-citizens is to damage their general appearance. The injury done by the ready-made truss dealer is far otherwise. He imparts a false confidence to the person who trusts in his instruments. Satisfied with the fact that they have an instrument the irksomeness of which is not unbearable, they are heedless or ignorant whether it satisfies all the requirements which should be demanded from it. Hence it is common to find persons who have worn a truss for years which, bought casually, and not adapted to the case, has offered scarcely any impediment to the aggravation of the rupture which it was intended to control. Probably the patient has first been aroused to the consciousness of the inefficacy of the instrument he bears by strangulation of the gut; or, as more commonly happens, the increasing size of the rupture has compelled his attention to the insufficiency of the truss.

Next in importance to the adaptation of the spring is the construction of the pad. This should be sufficiently hard to resist pressure well, yet yielding enough to adapt itself readily to the inequalities of the surface and avoid painful friction. Many materials have been used and are in use. Ordinarily the pad is constructed of cork thickly covered with leather, or of leather variously stuffed and fixed upon a metal framework. Inflated pads have also been fabricated, but sooner or later the contained air transudes through the walls sufficiently to affect the configuration; moreover, they are liable to accident. After much painstaking and experiment, I have come to the conclusion that a pad stuffed with fine dry sand is of all kinds the best. The material is sufficiently mobile to adapt itself to the surface to which it is applied, yet is unyielding enough not to lose form after long application. No other kind of pad has given me so much satisfaction.

(*a.*) *Scrotal rupture.*—Scrotal rupture is an inguinal rupture which has protruded so far as to extend into the scrotum. It is a form of hernia which could not occur except from neglect of a previous inguinal rupture. If every inguinal rupture could be properly treated, scrotal rupture would hardly be known. The latter usually takes several years in its formation. It sometimes attains huge proportions. I have frequently seen among the Chelsea pensioners a rupture of this character reaching as low as the knees. In this extreme state of protrusion there is no hope of returning the bowel to the abdomen and retaining it there. The only plan of relief which can be adopted is to place the tumour in a strong linen bag, which is suspended from the neck by straps. By this means the patient is enabled to carry more easily the hernial mass.

When a scrotal rupture is of smaller size, it admits of being treated mechanically. But the difficulty of retaining the bowel in the cavity of the abdomen is perhaps greater in this form of rupture than in any other. In my opinion, there is but one kind of truss which can be relied upon for its relief. This truss is formed of a padded pelvic spring of ordinary construction, but the pad, instead of being pear-shaped or oval, is fusiform, the lower prolongation being attached to a perineal strap. This strap, being carried round the posterior part of the thigh opposite to the rupture, and fastened to the pelvic spring, keeps the pad firmly fixed along the whole length of the canal along which the bowel escapes (Fig. 140.)

Fig. 140.



Some time ago I constructed, at the suggestion of Mr. Erichsen, for a wealthy Parsee, who suffered from double scrotal hernia, a double truss peculiarly arranged. The hernial rings in this case were so enlarged that the hand could be passed through them. The truss was formed of a pelvic metal band, padded, from which depended in front, immediately over the hernial rings, two movable steel plates. These plates could be moved upwards and inwards by means of a ratchet-screw. By this arrangement the rupture was controlled.

A truss for inguinal hernia, constructed upon this principle, has recently been patented, the patentee evidently not being aware that his design had been anticipated.

Sometimes, when the scrotal protrusion is very recent, and the patient is not likely to take heavy exercise, an ordinary inguinal truss, furnished with a very strong spring and a thick pad, will answer every useful purpose.

Elastic belts with a fusiform air-pad have been used for scrotal rupture both in this country and on the Continent. But from the yielding of the elastic material there is great danger of the bowel descending behind the pad. As a rule, indeed, the force with which the bowel protrudes far exceeds that of any elastic force which can be applied.

In applying a truss for the relief of scrotal rupture, as in inguinal rupture, the patient should be placed in a semi-recumbent position, the spring being first placed around the body in its proper place. Then, the protruded bowel having been returned into the abdomen, the pad is adjusted and the truss secured.

(*b.*) *Congenital rupture.*—Children as well as adults are liable to rupture, and the former suffer particularly from a peculiar variety of inguinal rupture which dates from the time of or soon after birth. Towards the termination of intra-uterine life the testicles pass from the abdomen into the scrotum, carrying before them a pouch of the peritoneum. In the natural order of things the mouth of this pouch, after the descent is completed, closes. But at times this does not occur, and the intestine is then apt to follow the testicle and protrude into the pouch, constituting congenital rupture. This, like other forms of infantile rupture, is readily susceptible of cure by mechanical means if due care be exercised. The means to be adopted is a truss constructed like the one described for scrotal hernia. This will retain the bowel in the abdomen and secure accurate apposition between the walls at the entrance of the hernial sac and obliteration of its mouth. In adapting a truss to a child, the pad should be sheathed in soft flannel, and the spring guarded by oiled silk or some other material impermeable to water. It is necessary that the instrument should be worn night and day, else the benefit gained by its use during the former period would be lost during the latter. With care on the part of the nurse a congenital rupture may be cured in a twelvemonth; but the truss should be worn at least three years, to avoid the risk of another protrusion of the intestine.

Cases occasionally occur in which the testicle has not descended lower than the inguinal canal and has remained fixed there for several years. I have occasionally had to construct a truss to prevent the return of the testicle into the abdomen and facilitate its further descent. Although the subject does not come strictly within the scope of this chapter, I may be permitted briefly to mention it here. In several cases, from nine to fourteen years of age, sent to me by Mr. Curling, I applied a truss the pad of which rested close above the testis as it lay in the inguinal canal. At the point where the pad approached the testis it was deeply notched. This treatment succeeded well, preventing any return of the testis and accelerating its descent.

Infants suffer also from ordinary inguinal rupture. Its presence is shown by a slight swelling in the groin when the child cries. An exceedingly light truss, made after the pattern of those already recommended, suffices for the treatment.

B. *Femoral rupture.*—This form of rupture, as already stated, occurs in the hollow of the thigh. It is most commonly observed in women. The relative liability of males and females to femoral hernia may be gathered from the following data given by Mr. Lawrence. Out of 83,584 patients examined at the Truss Society in 28 years, 699 males had single femoral and 169 double femoral rupture, whilst there were 5511 females with single and 1608 females with double femoral rupture; making the total number of males suffering from this malady 868, and of females 7119.

Owing to the course of the protruded intestine passing beneath, and then in front of, the tense ligament known as Poupart's, in reducing this form of rupture pressure must first be exercised downwards, and subsequently upwards towards the femoral ring.

A femoral rupture may vary in size from a hazel-nut to a well-sized pear. Dr. Hull states that he has seen a rupture of this kind as large as a child's head. In femoral hernia there is considerable danger of strangulation.

The truss which is needed to restrain this kind of rupture is distinguished by a peculiar shaped pad. This is so formed as to exercise pressure just below Poupart's ligament when the patient flexes the thigh upon the body, as in walking or sitting.

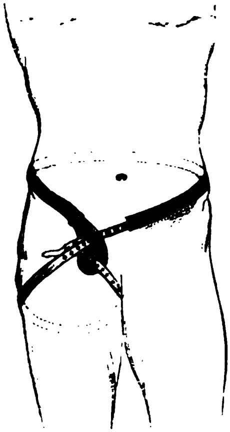
Three forms of truss are chiefly used for the treatment of femoral rupture.

All possess the ordinary steel-spring pelvic belt.

In the first (Fig. 141), the spring is curved downwards so as to rest above the femoral region, and it is fitted there with a pad of the character just described.

The second is furnished with an inflated india-rubber pad. This arrangement answers admirably for old-standing cases. It proves effective,

FIG. 141.



indeed, when the patient is even racked with cough or undergoes severe muscular exertion.

The third has a self-adjusting pad, attached to the spring by a steel slide. This variety of truss is useful when the patient takes horse exercise.

In applying the truss in cases of femoral hernia the patient should place himself in a semi-reclining posture, as when seated in an easy chair. The thigh, moreover, on the affected side should be moved inwards towards the opposite side, so as more fully to relax the tense tissues. The truss should then be passed around the pelvis and the pad allowed to rest upon the abdomen, so as to be in readiness to be placed over the hernial ring when the bowel has been restored to the abdomen. The rupture having been reduced, the pad is placed over the orifice of protrusion, namely, the centre and upper margin of the thigh. Next the straps shown in Fig. 141 must be fastened, the one across the abdomen, and the other around the thigh. The patient, then standing erect, may complete the adjustment of the straps according to his sense of comfort.

If this plan be not pursued, great difficulty may be experienced in fitting the truss effectively. Not unfrequently a cause of imperfect adjustment of the truss is the partial reduction of the rupture. This is apt to occur with patients who have not acquired facility in returning the prolapsed bowel and fixing the instrument.

It is fortunate that femoral hernia is rare in children, for it is difficult to obtain from nurses the care necessary for its mechanical treatment.

Femoral rupture is occasionally double, and it may occur with other forms of hernia.

I recently saw a young lady who had a femoral rupture on the right side and an inguinal rupture on the left. There were also two ventral protrusions and a strong tendency to umbilical. In this case an elastic belt kept the ventral and umbilical ruptures in check, while a double truss, having an inguinal pad at one end and a femoral pad at the other, kept the two other ruptures under control.

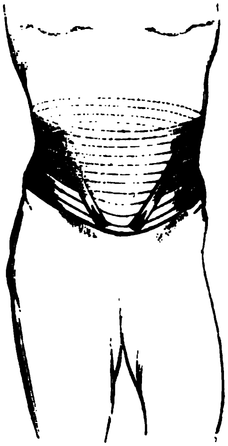
A femoral truss requires more care in construction than any other form. It must be shorter in the neck, owing to the position of the rupture, and it is necessary to give an oblique and upward direction to the "set" of the spring.

c. *Umbilical or Navel Rupture.*—Of all ruptures the umbilical is the simplest to control. Several ingenious contrivances have been devised for its treatment, especially by French mechanicians. This variety of rupture appears, indeed, to be more common among our neighbours across the Straits than among ourselves.

The simplest apparatus used is a broad elastic bandage, formed so as to sustain the whole weight of the abdominal viscera, and carrying a pad which rests against the umbilical orifice and localises the force there (Fig. 142).

The success of this arrangement depends chiefly upon the construction of the pad. Too commonly

FIG. 142.



it is conceived that an umbilical rupture protrudes through a simple circular orifice, and that all that is needed to check it effectually is to fill up this orifice in the same manner as a cork fills the mouth of a bottle. This is a most mischievous error. For as the edges of the umbilical ring are capable of dilatation, to occupy the orifice with a hard substance is to exaggerate the very evil which primarily led to the protrusion of the bowel. In constructing a pad for this variety of rupture it should be made of a size somewhat larger than the umbilical ring, and slightly convex on the ventral surface. Thus formed, a pad rests easily upon the abdomen, and it will not bury itself in the ring, interposing an obstacle to the closure of the abnormal aperture, while preventing the exit of the bowel. The best substance of which to construct the pad is flannel. This should have above it a thin layer of sand, the whole being covered with chamois leather.

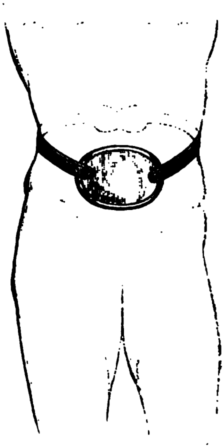
Sometimes the force with which an umbilical rupture protrudes is so great that no elastic bandage can hold it in check, unless the resilience is increased to an injurious extent. Under these circumstances the following truss will usually be found successful. An oval, padded, metal plate is adapted above the umbilical aperture, and kept in position by two metal springs, which are attached by hinges to a spinal pad (Fig. 143).

In a recent severe case, put under my care by Dr. Pollock, this form of truss proved eminently successful after the unavailing trial of a large number of contrivances.

This truss also is found to be exceedingly serviceable in counteracting weakness of the linea alba and a tendency to rupture in its course.

I lately saw in Vienna a form of umbilical

FIG. 143.



truss in which the pad was contrived to move slightly outward when the patient coughed. In England a helical spring has occasionally been fixed to the pad for a similar purpose.

Occasionally a leathern belt carrying an oval pad of the same material, and furnished with elastic fastenings, is found serviceable. This form of truss is very advantageous for use during the night if the patient is affected with severe cough, which may render it inadvisable to discontinue at any time the use of a truss.

Generally, umbilical ruptures are readily reduced, but sometimes the protruded intestine cannot be returned into the abdomen. The truss which is adapted for irreducible umbilical rupture is constructed as follows :—A hollow padded plate is fitted accurately to the tumour, and retained in position by two hinged springs, attached to a spinal pad. To prevent downward displacement of the truss, straps are attached to the upper part of the pad, carried over the shoulders like braces, and affixed to the spinal pad.

Infancy is the period when umbilical rupture is most common. This arises from the imperfectly or insecurely closed state of the navel at this period of life. An elastic bandage, about three inches deep, and carrying an air-pad, is the truss best adapted for an infant. This bandage should be laced at the back, so as to admit of enlargement as the child grows. Care must be taken that the pad is not too conical, else it would enter the umbilical ring and dilate it still more ; or too flat, lest the intestine should occupy the aperture, although not passing beyond, thus retarding its closure. In severe cases of infantile umbilical rupture a lightly constructed steel truss, after the pattern of that previously described (Fig. 143), may be used.

Out of the immense number of cases of umbilical rupture in infants which I have treated, I do not remember one which has permanently resisted treatment.

As a general rule, adult umbilical rupture is rare, except among those individuals to whom Mr. Banting addressed his world-renowed precepts. Out of 83,854 cases of rupture noted in Mr. Lawrence's statistics, only 644 males and 2775 females were affected with the umbilical form simply, but 2289 males and 1401 females suffered from this variety of rupture in conjunction with other kinds.

D. *Ventral Rupture.*—When the intestine makes a way through the abdominal walls in any part except at the groin, the navel, or in the femoral region, it is termed a ventral rupture.

This form of rupture is not difficult to manage. It is usually controlled readily by an elastic belt with a firm pad above the protrusion.

A short time ago a patient was sent to me by Mr. Paget, affected with ventral rupture, and who suffered from a remarkable weakness and flaccidity of the abdominal walls. There were several ventral protrusions, and on attempting to support these the walls yielded elsewhere. He had also two large scrotal herniæ. The oldest-standing scrotal rupture admitted solely of being supported by a suspender. The other scrotal rupture was controlled by a steel truss. The ventral herniæ were held in check by a carefully adapted elastic bandage, with suitable pads. The patient was subsequently enabled to take daily walking exercise with comparative comfort.

Weakness of the linea alba has already been referred to. Rupture along this line is to be dealt with as any other form of ventral hernia. When the aperture of protrusion is vertical—in fact, a slit, as it were—as sometimes happens, a double longitudinal pad is required.

E. *Vaginal Rupture.*—This form of rupture is best restrained by an instrument thus constructed. A steel spring, similar to the ordinary truss-spring, passes around the pelvis. From the centre of this spring behind, a curved steel band descends, carrying at its free extremity a conical pad, supported on a spiral coil. The pad is arranged so that it can be applied directly upon the seat of rupture.

F. *Rectal and Perineal Rupture* may be controlled by a truss constructed in the same manner as the vaginal truss, the posterior curved steel plate being modified to suit the requirements of the case, and the spiral coil being omitted for the perinæum.

G. *Pudendal Rupture.* The hollow cylindrical pessary, or a common female bandage, is required in this form of rupture.

H. *Obturator Rupture* may be restrained by means of a graduated compress and inguinal bandage, or, which is best, by an ordinary inguinal truss, of which the neck has been lengthened downwards, so that the pad may rest below the transverse branch of the pubic bone.

I. *Ischiatic Rupture* is held in check by a simple spring truss adapted to the case.

I have now briefly discussed the several varieties of mechanical appliances used in the treatment of rupture, both in adults and infants.

Few subjects have a greater social importance. The successful treatment of rupture closely affects the well-being of a large number of the labouring population. The ruptured operative, unrelieved, is constantly exposed to danger of life, and he is too often, and that needlessly, a burden to the public. The charitable gift of trusses at our great hospitals demands greater care than, as a rule, it receives. An ill-adapted truss is a source of misery to the wearer, and it gives little security. It is not sufficient to give the patient an order to obtain a truss and pass the case over without further observation. The fitness of the truss for its purpose, and its just adaptation to the individual case, can only be determined after a more prolonged investigation than that usually given to the subject.

3. *Pendulous Abdomen.*—Among debilities of the trunk, that relaxed and flaccid condition of the abdominal parietes known as pendulous stomach or abdomen must be included. This troublesome condition most commonly occurs in women of a phlegmatic habit of body, who have borne several children in rapid succession. The distension of the walls of the abdomen in successive pregnancies has resulted in their permanent dilatation. The integuments become loose and flaccid, and fall down upon the pubes or the upper portion of the thighs.

Not unfrequently also in obese persons the abdomen becomes so loaded with fat as to project inordinately, and, from the diminution of the resistance of its walls and degradation of the muscular structures, it forms an unwieldly unstable tumour.

Both conditions of the abdomen give rise to much discomfort, but they admit of great relief from mechanical means.

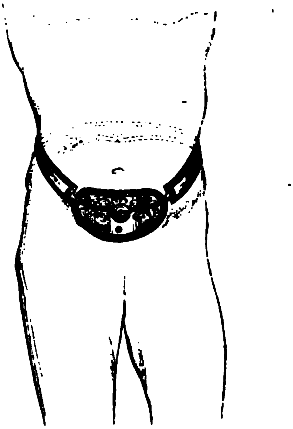
The most approved artificial support for slight cases of pendulous abdomen is a broad belt formed of elastic material. The finely reticulated tissue of india-rubber enveloped in silk is admirably adapted for this purpose. It affords uniform support, permits free movement, and is so porous that it does not impede transpiration.

More aggravated forms of pendulosity require a firmer support than that which is given by an elastic tissue. These cases are best dealt with by means of an abdominal truss of the following construction. To a large oval metal plate, well padded, two curved springs are attached, which pass around the hips and are buckled together behind. When the instrument is applied the pad is fixed upon the hypogastrium, and, acted upon and retained in position by the springs, it supports the depending abdomen.

This truss was originally designed by Dr. Hull. In his instrument the springs were attached to the pad by hinges, but no provision was made for adapting the truss to different degrees of distension of the abdomen. The French mechanicians overcame in part this difficulty, and arranged the springs so that their length could be extended or diminished. Even this change, however, did not meet every requirement, and on the suggestion of Dr. Gream I still further modified the truss. I placed within the pad a movable plate, acted upon by a key movement. By means of this plate and a ratchet adjustment the pressure of the truss can be augmented or diminished to any extent. Thus constructed, this form of abdominal support is found to be not only most effective but singularly comfortable to the wearer. The patient can adjust it to his own requirements with the greatest facility. The apparatus, moreover, has another important application, which will presently be described. The following drawing (Fig. 144) shows the form and adaptation of this truss.

In an abdomen pendulous from obesity an elastic bandage or the truss just described may be made use of, according to the necessity of the case. But a special belt, devised by Dr. Lever, is constructed for obese abdomens, and will be found most commonly useful. It is formed only in part of elastic material, is so shaped as to sup-

FIG. 144.



port the lower portion of the abdomen, and is secured behind by buckles; or else looped bands passed through each other are brought obliquely in front and secured to buttons above the pubes. A belt of this construction has recently been advertised by a country mechanician under the erroneous impression that it was a novel invention.

4. *Prolapse of the Womb.*—Formerly the almost sole method of treating prolapse of the womb mechanically was by the introduction within the vagina of a *pessary*. This instrument is still largely used. The commoner forms are globular or pyriform in shape, perforated in the centre, and made of boxwood. It is objected by many

authorities against these pessaries that they aggravate the evil they are intended to alleviate. They dilate still further the vagina which is already abnormally dilated. They are, moreover, a source of much irritation and discomfort. This may be true in respect to prolapse in an early stage. But in some of the older forms of the malady, common among the labouring classes, the old boxwood pessary is found most useful. It is cleanly, easily adapted, and inexpensive.

A useful form of pessary, constructed either of boxwood, gutta percha, or india-rubber, is disc-shaped. This is much less bulky and heavy than the globular or pyriform pessary, is less liable to give rise to evil consequences, but it is not so easily adjusted. This form of pessary, indeed, requires to be introduced by a medical man, while the globular and pyriform pessaries can be placed in position by the patient.

A very ingenious form of pessary was shown to me a short time ago by Mr. Spencer Wells. It was a light metal frame, with two lateral wings. The wings could be brought together by pressure, but on the constraining force being removed they opened wide apart. On this instrument being introduced closed into the vagina, and left there, the wings spread out, remained fixed, and received upon their upper surface the prolapsed womb.

Sponge- and air-pessaries are also constructed for cases which are not excessive. The air-pessary is an india-rubber pyriform bag, to which is attached a slight flexible tube, with stop-cock. The bag is introduced undistended, the air is forced in by means of a piston attached to the flexible tube, and when a sufficient degree of inflation is secured the stop-cock is turned, and the piston removed. This is an excellent and most convenient form of pessary.

Several modifications of the air-pessary have been devised. Thus, it has been made disc-shaped. Again, Mr. Salmon attaches a globular air-pessary to an external pad. Several years ago I constructed an air-pessary in which the distension arising from inflation was aided by a simple mechanical contrivance by means of which the greater transverse diameter of the pessary, when in position, was effectually secured.

But none of the instruments described equal in value the stem-pessary. This is supported by a perineal band, attached to a pelvic belt. The stem terminates in a small cup-like receptacle which receives the cervix uteri. The best form of this pessary is hollow, and constructed of gutta-percha or india-rubber. It affords more trustworthy support than the other forms of pessary described, does not dilate the walls of the vagina, and gives rise to little irritation.

The tendency of modern practice has been to do away with internal support in the treatment of prolapse of the uterus. It has been found in a great proportion of cases that the benefits to be derived from mechanical aid might be gained from external support merely. I am now chiefly called upon to treat prolapse of the womb without a vaginal pessary. For this purpose the abdominal truss described at p. 409 is invaluable. Dr. Gream has designated it an "uterine truss" from its excellent effect upon that organ. In severe cases a perinæal band with pudendal pad is added.

5. *Prolapse of the Rectum.*—In slight cases of prolapse of the straight gut, when mechanical aid is needed, an old fashioned T-bandage with a conical or hemispherical anal pad of ivory or gutta-percha is commonly adopted. The evil of this arrangement is that the pad tends to bury

itself within and dilate the anus—weakening still further, instead of fortifying, the action of the already too debilitated sphincter. To obviate this difficulty, I have constructed the following instrument:—From the centre of the posterior part of a well-padded pelvic belt descends a curved flat metal spring. This spring terminates in a disc of sufficient diameter to rest around the margin of the anus. The upper surface of the disc is occupied by a slightly convex india-rubber air-pad. When the instrument is in position the disc forms as it were a substitute for the sphincter; and, while the pad affords the necessary resistance to protrusion of the bowel, it effectually obviates any tendency to dilatation of the anus.

III.—DEFICIENCIES.

There are but few deficiencies of the trunk which come within the scope of the orthopractic mechanician. The chief of these are:

1. CLEFT SPINE.
2. DEFICIENCY OF ABDOMINAL WALLS.
3. DEFICIENCY OF STERNUM.

1. *Cleft spine* (*spina bifida, hydrorachitis*) is a congenital affection. The spinal processes and laminæ of some of the vertebræ are deficient from arrest of development during fœtal life. The membranes of the cord being unsupported bulge outwards, an excessive amount of fluid is secreted, and a fluctuating tumour is formed over the defective bones. The plan most frequently adopted in treating this malady is to apply moderate support. This is best effected by a leather or gutta-percha truss carefully moulded to the tumour and secured in position by broad bands.

2. *Deficiency of Abdominal Walls.*—A few years ago Mr. Henry Smith placed under my care a patient of his in King's College Hospital, who suffered from an entire absence of the anterior and lower portion of the abdominal walls. Through the aperture the bladder had protruded, whilst the ureters and urethra were exposed, and exuded urinary fluid. In addition the unfortunate patient laboured under double inguinal hernia, due, undoubtedly, to thinning of the muscular walls of the abdomen.

For this case I constructed a shield so arranged as to retain the hernial protrusions, and at the same time cover and protect the tender and sensitive bladder. A receptaculum was also appended for the urine. By this arrangement security against hernial strangulation, defence from external irritation, and cleanliness, were obtained, and the patient experienced great comfort.

3. *Deficiency of Sternum.*—This form of arrested development is so rare, that had not an example a short time ago attracted much attention among the profession in town, it might have been passed without notice. In the case referred to an altogether exceptional opportunity was afforded to study the action of the heart. It occurred to me, on seeing this case, that some mechanical protection of the thoracic viscera might be needed in lieu of the sternum in similar cases. It would not be difficult to construct a padded metal shield—an artificial sternum—and attach it to the thorax by a light cylindrical steel spring.

CHAPTER IV.

THE LOWER EXTREMITIES.

I.—DEFORMITIES.

Under the head of "Deformities of the Lower Extremities" are included—

1. CONTRACTED HIP.
2. CONTRACTED KNEE.
3. BOWED LEGS.
4. CLUB-FOOT.
5. DEFORMITIES OF THE TOES.

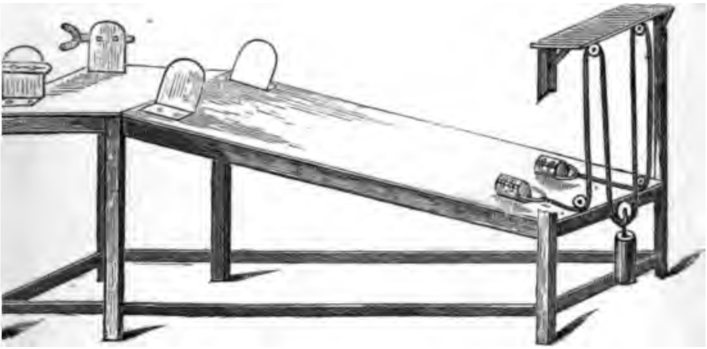
1. *Contracted hip.*—The mechanical treatment of this deformity presents many difficulties. Resulting, as a rule, from active or subacute mischief in the socket of the thigh, much circumspection is required in attempting to ameliorate contraction of the hip. On the other hand, without mechanical aid, medicine in these cases would be well nigh hopeless.

There is a variety of this deformity of rare occurrence, and which, being usually observed in connection with lateral curvature of the spine, is generally included among spinal distortions.

The hips become fixed from rigidity of the surrounding parts. The body cannot be held fully erect from spastic contraction of the flexor muscles of the thigh, and on attempting to sustain a perpendicular position, the pelvis appears to be tilted forwards as in anterior lumbar curvature. The mechanical treatment of a case of this kind is simple extension, and I have devised a couch for its application. This is so arranged as to allow the arms and upper part of the body to rest in a horizontal position, while the pelvis and lower extremities lie on an inclined plane, the angle of which is about 25°. A small crutch placed beneath each arm-pit fixes the shoulders, and a pair of padded plates, acted upon by horizontal screws secures the pelvis. On each ankle a padded band is fastened, to which leaden weights are fixed by cords running over pulleys at the end of the bed. These, when the bands are adapted, exercise traction upon the hip, and tend gradually to bring the legs to their proper length and position. After this object has been secured, the same form of appliance as that figured at page 332 is to be adopted, for the purpose of retaining the thigh bones in position.

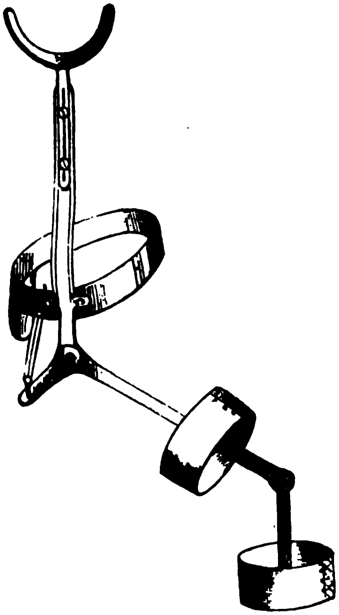
The external characteristics of contracted hip are flexion of the thigh upon the trunk and shortening of the leg. The foot does not touch the ground, and the patient cannot walk without crutches. Owing to the neck of the thigh bone being fixed at a considerable angle to the axis of the shaft, a difficulty is found in applying extending force. This difficulty is peculiarly felt if the disease has resulted in luxation of the head of the bone. In order to bring a sufficient amount of extending force to bear upon the flexed thigh, it is necessary to act by leverage, the fulcrum being invariably the pelvis.

FIG. 145.



I constructed the following apparatus (Fig. 146) for a patient of Mr. Weedon Cooke's, at the Royal Free Hospital, and as it permits free mus-

FIG. 146.

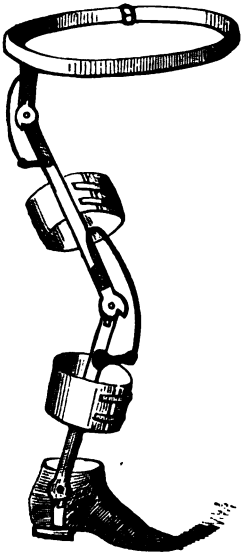


cular motion while the limb is being extended, it may be used with advantage in slight cases.

The instrument is composed of a lateral metal stem, extending from the arm-pit to the centre of the calf, and possessing free joints at the knee and hip. It is attached to the body by a padded pelvic band. At the centre of the stem, between the hip and knee joints, a padded metal band passes over the front of the thigh, while at the lower extremity there is a metallic trough, which receives the back of the calf. From the upper extremity of the middle (thigh) portion of the stem, a process projects backwards at right angles to the stem. This process is connected with the pelvic band by a powerful vulcanized india-rubber cord, the traction of which, converting the stem into a constantly acting lever of the first order, tends persistently to extend the thigh.

This instrument was very successful in the

FIG. 147.

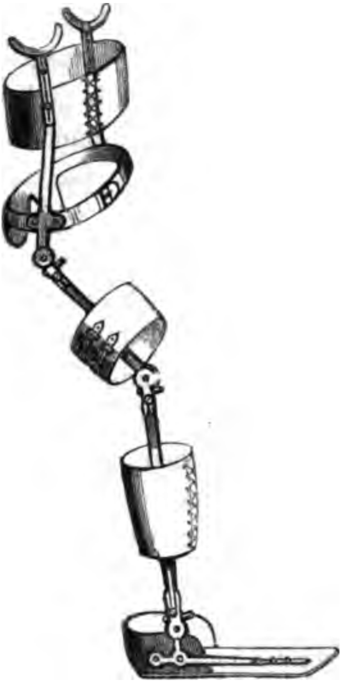


case to which it was applied. In a short period the thigh was completely extended.

Another instrument (Fig. 147), adopted in cases free from lateral deviation of the shaft of the thigh, consists of a metallic stem, which extends from the armpit to the sole of the boot, and is jointed at the knee, ankle, and hip. The latter joint is furnished with a powerful spring, formed on the gun-lock principle, and therefore constantly dragging the thigh downwards. The limb is secured to the lateral stem by thigh and calf troughs, the former passing in front of, the latter, behind the limb. There is also a pelvic band, which fastens the apparatus to the body.

An appliance (Fig. 148) which meets every requirement in cases of severe hip contraction, successfully combating and counteracting each abnormal deviation, deserves a more careful and detailed description. It is composed of a pelvic band, bearing two lateral uprights, upon which the arms rest, and from which strong laced bands pass around the thorax. Two gluteal plates are placed at the lower edge of this pelvic belt; these being intended to prevent the pelvic band from being horizontally rotated, or forced round upon the body, when the apparatus is extended; since

FIG. 148.



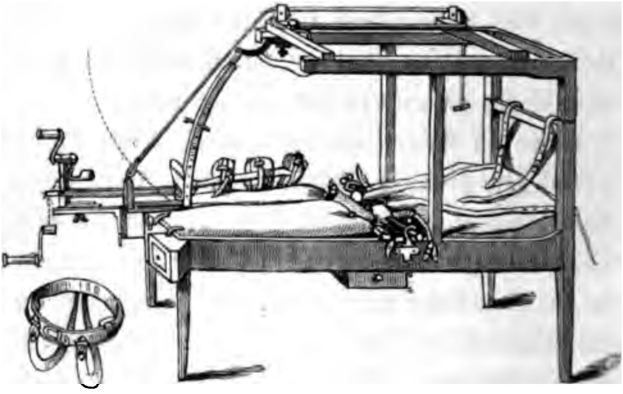
the contraction of the deformed limb induces a tendency to this displacement. At the lateral margin of the belt, and in apposition with the deformity, a powerful metal stem is screwed on which contains two rack-and-pinion centres; one to extend the thigh, the other to force the femur outwards. Occasionally, a third ratchet, which acts horizontally, is introduced; but this is rarely necessary, as the combined actions of extension and abduction, if carefully managed, will also rotate the limb. The stem is prolonged to the heel of the boot, rack-and-pinion axes being placed at the knee and ankle, for the purpose of overcoming any contraction which may have taken place at those joints. The thigh and calf are held within the instrument in suitable troughs; the thigh trough being, as usual, fixed in front of the limb, that for the calf, behind—thus they mutually counteract the flexion of the hip and knee.

This instrument, when managed with care, will effectually overcome every mechanical complication which is met with in contraction, not only of the hip, but also of the knee and ankle, no matter how severe. Sometimes it is necessary to add a second rack-and-pinion joint at the knee, for the purpose of overcoming lateral displacement of the head of the tibia (on a principle which will be discussed when contracted knee is considered), and, in like manner, if varus exists, a modification of Scarpa's shoe.

There is another movement necessary when actual luxation of the head of the femur has taken place, namely, that produced by an elongating screw placed at the thigh part of the apparatus, the object being to extend the thigh on the trunk. All the advantages offered by the various orthopædic beds which are employed on the Continent may be obtained by this instrument, with the additional one, that the patient is able to take some slight amount of exercise upon crutches.

When in Wurtemburg, several years ago, I visited Dr. Heine's establishment at Cannstadt, for the purpose of inspecting the various mechanical contrivances which are used in Germany for the treatment of deformities. His couch for the treatment of contracted hip has attained much celebrity. Mr. Hugman, in his work on 'Diseases of the Hip-joint,' has spoken very favorably of its use in severe cases, where other contrivances have been supposed to be inapplicable. But I believe that, in all cases, the apparatus last figured answers better. It is less irksome to the patient, and less injurious to the general health. Again, in Dr. Heine's apparatus, very little, if any, provision is made for those complications which are occasionally associated with contraction of the hip-joint—such as flexion of the knee to a right angle, lateral displacement of the head of the tibia, &c. I give a sketch of Dr. Heine's couch (Fig. 149), in order that the two forms of apparatus may be contrasted.

FIG. 149.

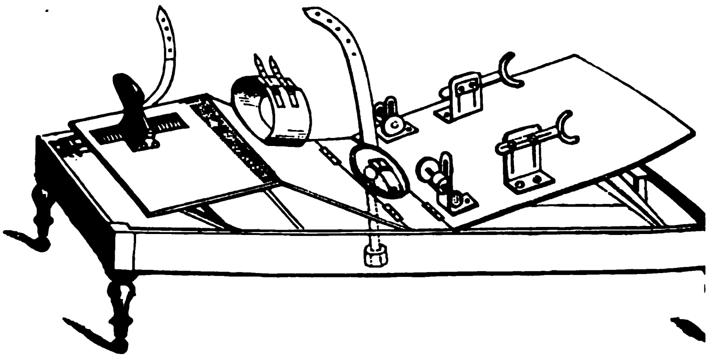


The well-known apparatus, called a "prone couch," is sometimes used in simple cases of contraction of the hip-joint, as the weight of the limb facilitates elongation; it is objectionable, however, on mechanical grounds, because the thigh and trunk are constantly kept in a bent position, thus tending to foster contraction of the flexors. But this plan of treatment is of great utility if adopted for the purpose of obtaining rest when the early symptoms of hip disease show themselves, although, under these circumstances, I consider the method proposed by Sir Benjamin Brodie to be infinitely superior.

This consists in carefully moulding a thick piece of leather to the pelvis and thigh, the leather being applied while *wet* and flexible, and allowed to dry and harden to the shape of the body. So perfect is the support thus formed, that it even exercises a control over the involuntary muscular motion which is frequently observed in these cases, and which sometimes induces sudden movement of, and disturbance in the joint. I have frequently applied these splints by the direction of Sir B. Brodie, Messrs. Fergusson, Quain, H. C. Johnson, Hilton, Erichsen, &c., and invariably found that the limb was held in a state of perfect rest by means of them.

The best adaptation of the principles laid down by Heine is to be found in a couch of the following construction (Fig. 150). It consists of a double inclined plane, and in order that the objection so constantly urged against this compound inclination—viz., that it produces great pressure upon the nates—may be avoided, the glutei rest upon a padded plate, which can be raised by a perpendicular screw, passing upwards from under the centre of the couch. Two pads are fixed by

FIG. 150.



long horizontal screws at each side of the couch, their office being to grasp the sides of the pelvis laterally, and in this way afford a fixed point of action for the extending mechanism. A strong padded band is placed over the thigh on the outer side of the limb affected, and in connection with the plane, another passing around the leg. As the angles of the plane are varied, so the thigh becomes extended upon the trunk; and as the pelvis can be raised at the same time, the joint may be readily restored to a normal position. There is also an extending metal stem, to promote lengthening of the limb.

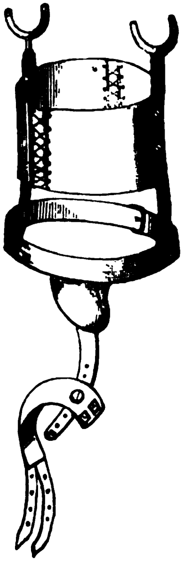
Various straps are fixed to the frame, with the intent that the pelvis may be secured firmly to it, the arm-pits being received by sliding and thickly padded metal crutches.

Sometimes a contraction of the hip-joint is at once overcome by placing the patient under chloroform, and then breaking away the adhesions around the joint by violence. I contrived an instrument, at Mr. Brodhurst's suggestion, which is intended to effect this end, and another for maintaining tolerably constant exercise of the joint, after the completion of the previous operation. The former of these contrivances consists of an ordinary "easy chair," to the seat of which a strong and well padded band is affixed, which, after passing over the pelvis, is fastened to the opposite side. At the back of the chair, near its upper margin, a powerful pulley is secured, through which a cord passes, terminating in a padded thigh band. The surgeon takes a position in front of the patient, and violently flexes the thigh by pulling the cord. Having allowed the limb to rest for a few days after this has been accomplished, the next apparatus employed consists of a strong wooden seat with a pelvic strap. Another strap passes under the perinæum, which is secured to the lateral margin of the seat. A pulley is screwed into the ceiling, through which a rope runs. This rope is attached to the thigh by a band at one end, and it is held by the patient at the other. An uplifting of the thigh follows when this rope is pulled, and if the thigh band is also furnished with another rope, passing through a pulley fixed in the ground, alternate flexion and extension is readily set up, ultimately securing mobility in the joint.

Bonnet suggests a somewhat similar apparatus, but he employs a handkerchief to hold the thigh, which, I know from experience, is insufficient fully to fulfil the object for which it is proposed.

A badly contrived instrument occasionally employed for cases of contracted hip is constructed as follows (Fig. 151) :—It consists of a pelvic band bearing two lateral uprights, one of which has a perpendicular spring at its lower border, which supports a bandage intended to embrace the knee. My reasons for thinking that this instrument is extremely ill-devised are, firstly, that the posterior stem must be constantly in the way whenever the patient attempts to sit down ; secondly, that the lever which is applied

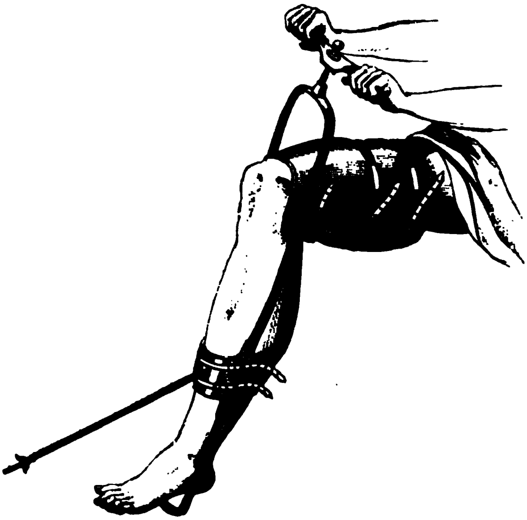
Fig. 151.



for the purpose of extending the thigh would prove absolutely useless in cases of rectangular contraction, for it would be far more likely to turn the apparatus round upon the body, than to diminish the contraction; thirdly, that the lever can rarely, if ever, be kept in the mesial line of the thigh, where it undoubtedly should be, in order that effective mechanical traction may be used. I would not have mentioned this instrument, had I not found that it has been strongly recommended to surgeons as an efficient instead of an objectionable agent in the mechanical treatment of contractions of the hip-joint. The gentleman who devised the apparatus may be a good surgeon—I am quite sure that he must be a very poor mechanist.

Bonnet invented a very ingenious apparatus for securing rotation of the thigh, which will be best mentioned in this place. The form and application of the mechanism will be at once understood from the accompanying drawing (Fig. 152).

FIG. 152.



The patient being seated, the weight of the trunk suffices to fix the pelvis without extraneous aid. The axis around which the femur executes its movement of rotation, proceeds from the point of union of the superior two thirds with the inferior third of the leg. Thus arranged, it seems to Bonnet to represent truly the fictitious axis around which the inferior member, slightly flexed, executes its movements of rotation inwardly and outwardly.

2. *Contracted Knee.*—Contraction of the knee (Fig. 153) is due either to a shortening or spastic contraction of the muscles of the back of the thigh or to chronic disease of

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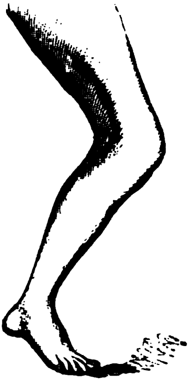
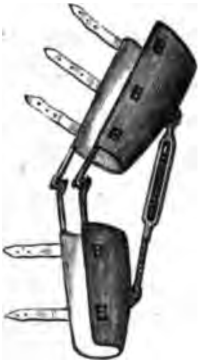


the joint. When the cause is muscular the mechanical treatment is invariably immensely assisted by a division of the tendons of the semimembranosus, semi-tendinosus, popliteus, and biceps flexor cruris muscles, as one of the greatest obstacles to extension is thereby removed. Nevertheless, there is one point relative to tenotomy which, I believe, has escaped observation until I directed attention to it five years ago, *simply because its solution happens to be purely mechanical.* It is this, that there is a slight posterior luxation of the head of the tibia in almost all cases where this remedy has been resorted to. The explanation of this occurrence may be simplified by a description of the apparatus in ordinary use for straightening the knee joint (Fig. 154). When the flexion of the knee is trifling, the instrument usually employed for mechanically extending it, is a padded wooden or metal splint, hinged at the knee, and extended by means of a male and female screw; there is also a knee-cap.

Any one examining this drawing, will find that upon extending the apparatus, the greatest amount of resistance must be found, first, at the anterior surface of the knee, over which the

FIG. 154.



knee-cap passes; secondly, against the calf; and thirdly, at the thigh. The centre joint becomes the fixed point of rotation for the thigh and leg levers, thus diminishing the angle of the knee; but as the *tibia* is acted upon by the lower band and knee-cap in such a manner that it acquires a disposition to rotate backwards around its own centre, and as the same thing cannot occur at the thigh, because it is firmly fixed to the pelvis, posterior luxation of the head of the tibia must take place, although this is generally of so small an extent as to be hardly noticeable.

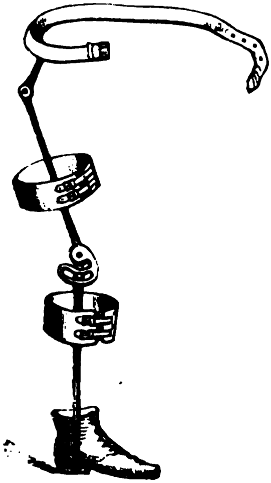
If this occurs where no *tenotomy* has been performed, how great must be the increase given to posterior rotation of the tibia, when the muscles connecting the leg with the thigh are severed; for then the whole power exercised by the extending apparatus must necessarily be so directed as to thrust the head of the tibia backward.

Notwithstanding this objection, tenotomy offers immense advantages; but these are greatest where the instrument for extension is so constructed that it will effect the intended result without producing the untoward action just described. Upon this ground, again, it must be admitted that, unless a mechanist be sufficiently competent to comprehend perfectly the new directions taken by bones under certain abnormal circumstances, he will be incapable of affording the surgeon that assistance which the latter is justified in expecting at his hands. When the apparatus is properly made, it should embrace the head of the tibia posteriorly, and ought gradually to advance that point as the knee becomes extended by the remaining portions of the appliance. If required for a slight contraction, this is best effected by passing a strong webbing band at the back of the knee, just below the condyles, and rendering it tighter as the instrument approaches towards a straight line.

The instruments used for the purpose of overcoming contraction of the knee are so numerous that it would be futile to attempt to describe even a tenth of them. Those most frequently adopted, together with sundry of recent invention, are figured in the following pages.

The first (Fig. 155) consists of an instrument with a hip-joint, which is attached to the pelvis by a padded band. At the knee there is a semicircular disc, through an aperture in which a screw passes to a hole in the leg-stem, into which it is

FIG. 155.



received. The lower part of the instrument is attached to a boot, the calf and thigh being embraced by padded bands. A webbing band, attached to the thigh and leg stems, surrounds the knee, passing in front of it. Upon bringing the instrument into action, the leg is first of all extended by the force of the hand, and the segmental screw is then tightened, thereby diminishing the angle formed by the leg and thigh. This instrument is only intended for use in very slight cases.

The next kind of instrument (Fig. 156) is

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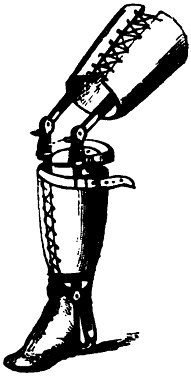
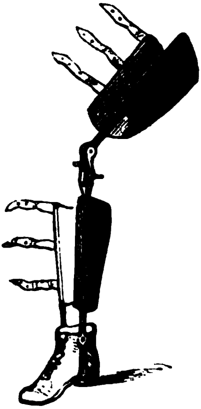


composed of two metal troughs, one for the reception of the thigh, the other of the leg.

These troughs are joined by two lateral stems, having ratchet joints situated at their centres. A webbing band passes at the back of the apparatus, just below the centre of the knee-joint, which prevents posterior luxation during the extension of the contracted limb. When this instrument is set in action by turning the tangential screws at the knee, the ensuing extension of the two femurs which form the thigh and leg stems, induces pressure upon the patella, together with a change in the angularity of the limb. This instrument is peculiarly well calculated to overcome the distortion in all ordinary cases of contracted knee, and it is likewise so simple as regards its mode of application, that the occurrence of an error in mechanical manipulation is almost an impossibility.

Where, as sometimes happens, contraction of the knee in its mesial plane is accompanied by lateral inversion, the following instrument (Fig. 157) will be found available. One padded trough receives the thigh, another the calf, these two being connected, on the outer side, by a single lateral stem, furnished with two rack-and-pinion joints, each acting at right angles with the other. A strong knee-cap is then fixed to

FIG. 157.



the extremities of the leg and thigh troughs. When acting mechanically upon the limb with this instrument, the one axis entails extension, and the other lateral eversion;—thus the knee is gradually restored to its proper position.

I have recently devised a plan for the extension of the knee in ordinary cases, by adapting the tractile force of powerful india-rubber straps to the instrument, in such a way as to induce straightening of the knee, and, at the same time, admit of some slight amount of motion in the joint. This plan is practically carried out (Fig. 158), by adjusting two troughs to the limb,—one for the

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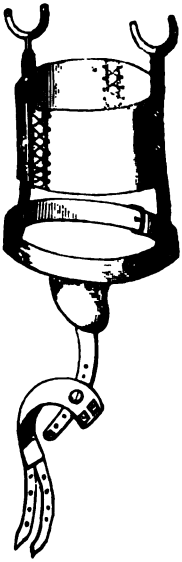

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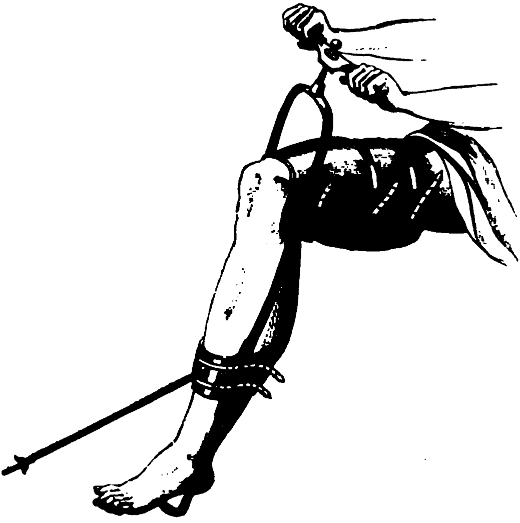

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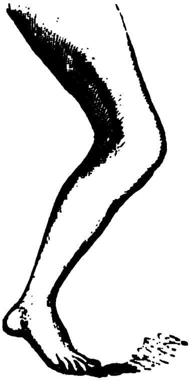

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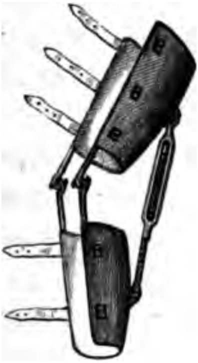

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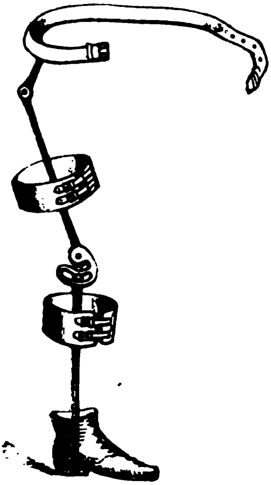

with a hip-joint, which is attached to the pelvis by a padded band. At the knee there is a semicircular disc, through an aperture in which a screw passes to a hole in the leg-stem, into which it is received. The lower part of the instrument is attached to a boot, the calf and thigh being embraced by padded bands. A webbing band, attached to the thigh and leg stems, surrounds the knee, passing in front of it. Upon bringing the instrument into action, the leg is first of all extended by the force of the hand, and the segmental screw is then tightened, thereby diminishing the angle formed by the leg and thigh. This instrument is only intended for use in very slight cases.

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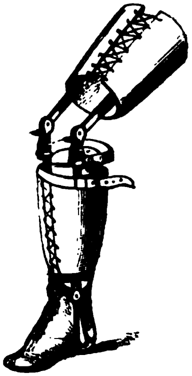

composed of two metal troughs, one for the reception of the thigh, the other of the leg.

These troughs are joined by two lateral stems, having ratchet joints situated at their centres. A webbing band passes at the back of the apparatus, just below the centre of the knee-joint, which prevents posterior luxation during the extension of the contracted limb. When this instrument is set in action by turning the tangential screws at the knee, the ensuing extension of the two femurs which form the thigh and leg stems, induces pressure upon the patella, together with a change in the angularity of the limb. This instrument is peculiarly well calculated to overcome the distortion in all ordinary cases of contracted knee, and it is likewise so simple as regards its mode of application, that the occurrence of an error in mechanical manipulation is almost an impossibility.

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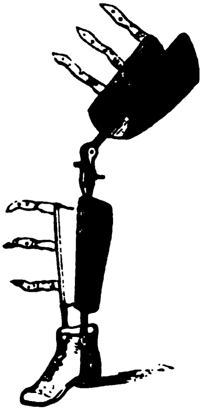

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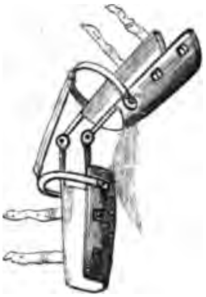

thigh, the other for the calf,—and joining them together by two lateral levers, each *freely-jointed* at the knee. Two semicircles of metal are fixed to these levers, midway between the two troughs, for the purpose of affording attachment to strong bands of vulcanized india-rubber. The constant traction of this elastic substance maintains a persistent *extensile* force upon the contracted muscles, and, if the action of the apparatus is assisted by tenotomy, the limb soon becomes restored to a normal position.*

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* A strong knee-cap is attached to all these instruments with a view of preventing the knee from being raised from the apparatus when mechanical power is applied, and as a necessary counter-resistance to the extension produced by the lateral levers.

In the apparatuses which I have described as being applicable for the restoration of a contracted knee to the straight position, it has frequently been found that, owing to the amount of yielding of the muscles which form the back of the leg and thigh, the lateral stems have become vertical, the limb, notwithstanding, retaining a slight amount of angular retraction. In order that I might obviate this drawback, I recently devised an apparatus by the action of which power is so applied, from the very moment at which extension commences, that the knee is drawn backwards, whilst the leg and thigh are simultaneously thrust forward. Although all the former instruments induce extension of the leg and thigh, none of them resemble this one, in aiming at an active depression of the angle of flexion at its apex. The others simply offer a passive resistance over the anterior surface of the knee, while the leg and thigh are being extended.

This instrument is composed of two steel levers (Figs. 159 and 160), joined together by a ratchet-joint at the back of the knee, by means of which they can be so moved as to coincide with any angle of contraction. A

FIG. 159.

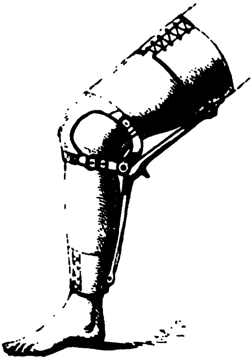
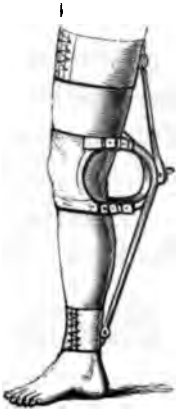


FIG. 160.



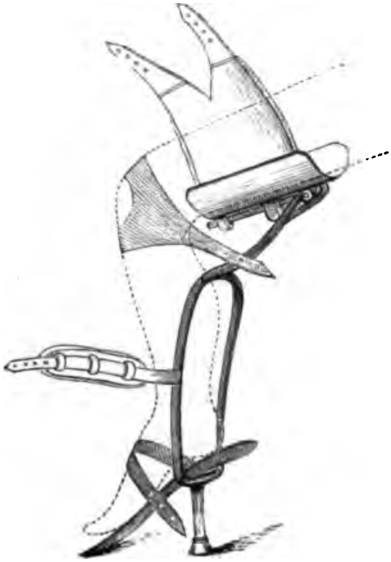
padded band, passing over the back of the thigh, is attached by a hinge to the upper extremity of the levers; this allows of a ginglymoid motion in them when they are acted upon by the ratchet-screws. Another band is attached to their lower extremity by a similar hinge. Four small steel arms spring from the ratchet hinge in such a manner that they pass on either side of the knee, giving attachment to a strong leathern cap, which crosses over the front of the joint.

When this cap is adjusted, and the ratchet screw is moved in a posterior direction, the two levers are extended anteriorly; but, as their extremities are hinged to the bands which surround the calf and thigh, the entire posterior stem acquires a tendency to backward motion, drawing the knee, of course, in the same direction. This action may be continued, until the ratchet centre reaches a point *behind the vertical line*, or, in other words, reverses its angle; the entire restoration of the great bones of the limb to a vertical position being thereby ensured.

It is difficult to describe this instrument satisfactorily; but the results obtained by its use are indisputably favorable. It fairly removes that contractile tendency which always remains, where the angularity has not been completely conquered, at the same time that it prepares the knees for the reception of exercises, which must be employed, in all cases, ere motion can be restored to the joint after it has been mechanically extended.

Although not strictly an instrument for contracted knee, the following apparatus will be found very useful, where there is a permanent

FIG. 161.



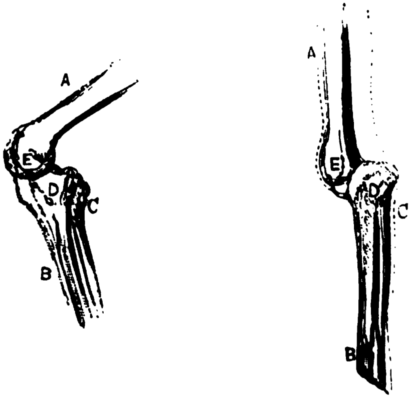
shortening in the length of the leg, from anchylosis :—

It consists of a padded thigh-trough, attached to a powerful metal stem by a hinge; the stem bifurcating just above the calf, and joining a foot-plate below. A small tube, or socket, is sunk in the lower surface of the foot-plate, for the reception of a wooden pin, which fills up the space existing between the foot and the ground. A strong knee-cap passes over the patella and secures the leg firmly to the apparatus.

When the patient uses an instrument of this kind, his weight is received by the thigh-trough, and transmitted thence to the ground, so that the knee is guarded from all strains, while the tendency to vertebral curvature, which is always induced by a contracted state of the lower limb, is arrested and negatived.

Another condition assumed by the knee, for which very complex mechanisms have usually been constructed, is known as *posterior displacement of the tibia, beneath the extremity of the femur.* Where this is present, any attempt at reducing the angle of the knee by an instrument which possesses but one knee-axis, must not only be ineffectual, but will positively tend to increase the displacement of the tibia. The reason of this needs explanation. Upon carefully examining a knee so contracted that the head of the tibia shows itself posteriorly beneath the extremity of the femur, it will instantly be apparent that another centre of motion must be established in lieu of that on which the leg flexes in its normal state; and, consequently, that, in the treatment of the case, this false centre must first be

FIG. 162.



A. The femur.
B. The tibia.
C. The head of the tibia displaced posteriorly.
D. The false centre around which the displaced bone rotates posteriorly.
E. Natural axis of the knee-joint.

so advanced as to be re-established at the point where the true centre originally existed, before the limb can be restored to its vertical position (Fig. 162).

Upon attempting to extend the knee by any ordinary appliance, the mechanical result must be to make the tibia rotate upon the false axis D, which would leave the head of the bone in a position of backward dislocation, even if the extension succeeded in overcoming the abnormal contraction. In order to avoid this, the head of the tibia must be advanced anteriorly beneath the extremity of the femur, concurrently with the attempt being made to extend the limb. The instrument best fitted to effect this is made as follows (Fig. 163):*

A metal stem, containing two free joints, so arranged as to correspond by their centres with the axes of the extremity of the femur and head of the tibia respectively, passes down on either side of the limb, to which it is attached by padded metal thigh- and calf-troughs. When applied, this instrument conforms itself with tolerable

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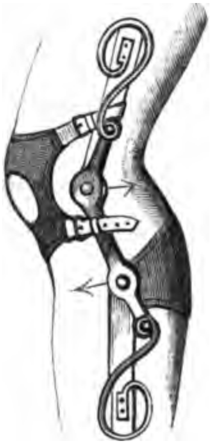
* An admirable description of this instrument has appeared in the 'Lancet,' penned by Mr. Erichsen, who originally suggested its construction.

FIG. 163.

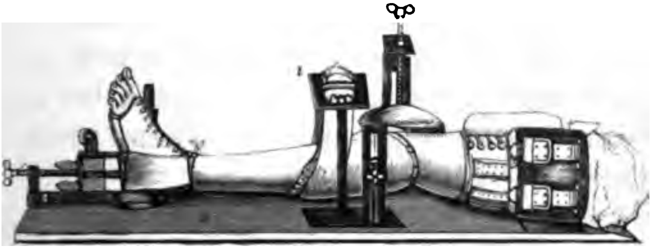


accuracy to the shape of the malformed limb. A perpendicular spring is fixed to that portion of the apparatus which is situated in a line with the thigh, above the first of the free centres, the action of which spring presses the head of the femur backwards; while below the second centre, and in a line with the tibia, another spring is attached, the mechanical power of which urges the head of the tibia forwards; thus two antagonistic forces are obtained, both tending to bring the head of the tibia beneath the extremity of the femur, and, at the same time, extend the angle of contraction. If the deformity is one of very great severity, it is better to use ratchet-screw centres than to act by the power of strong springs. This instrument requires to be managed in a peculiar fashion, when in action, since the success of a case will depend upon the ratchets being screwed in a proper order. It is thus used:—After applying the instrument, so adjusted by means of the screw centres that the axes of its joints shall coincide with those of the femur and tibia, the first movement which must be given is that of flexion of the lower centre, by which the head of the tibia is thrown forwards; but this also increases the angle of contraction. If the upper rack be now extended, the entire tibia is made to rotate in an anterior direction beneath the head of the femur, and the angle of deformity is considerably diminished. By following in this sequence, when acting upon the distortion, the limb can be gradually restored to a normal condition, without fear of the posterior luxation remaining unreduced. It will be apparent that, in the second of the actions just described, the upper axis becomes a fixed point, around which the radius of motion, which takes place between it and the lower centre, rotates;

and, as the lower centre is connected with the leg-trough, the tibia must, of necessity, advance with the instrument, and in this way complete the extension and replacement of its head. The spring-instrument acts in like manner, but, owing to its being self-adapting, its action cannot be so readily regulated.

An apparatus (Fig. 164) sometimes recommended for the treatment of a deformity of this description* consists of a mahogany board with perpendicular lateral stems, to which a webbing band, passing like a sling under the head of the tibia, is attached. The thigh is firmly bound to fixed pads belonging to the board, and the ankle is grasped by a bandage which is secured to a

FIG. 164.



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* Little 'On Deformities,' page 80.

horizontal screw, the object of which latter appendage is, elongation of the leg. A pad, regulated by a screw, is placed over the anterior and inferior surface of the thigh, pressing the femur downwards, and affording counteraction against the webbing band which passes underneath the head of the tibia. There is also an arrangement for the prevention of lateral displacement of the head of the latter bone. This instrument, although very ingenious, considering the period at which it was devised, is far too clumsy to be generally adopted in the present advanced state of science, as it not only restricts the patient to his couch, but is entirely useless where the knee presents much posterior flexion.

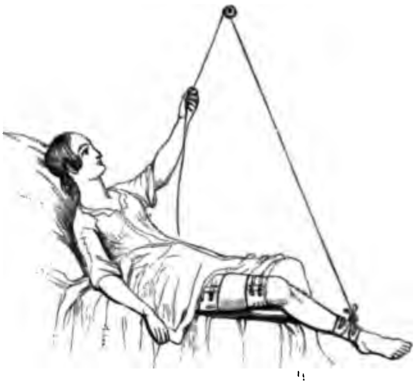
Posterior luxation of the tibia without *angular contraction between the leg and thigh,* is another deformity incidental to the knee. An instrument for its treatment (which I constructed for a patient of Dr. Little's, at his suggestion) is thus made:—Two lateral levers, hinged at the knee, are attached to the limb by thigh- and leg-troughs, so proportioned that the upper trough embraces the thigh from the ischium to the commencement of the condyles, while the lower one surrounds the leg from just above the malleoli to the tibial tuberosities. At the back of each trough, and to its centre, a small hook is fixed, and on these hooks a ring of vulcanized india-rubber is stretched, the action of which flexes the apparatus, and thus overcomes the disposition of the knee to backward flexion. From the elastic nature of the applied power it is impossible that any permanent contraction of the knee-joint can result.

I need scarcely remark that a strong knee-cap is a necessary and constant appendage to all contrivances intended to act upon the knee-joint; since, if this precaution were neglected, the angle formed by the leg and thigh would remain undiminished, and the efficiency of the mechanical appliance would be necessarily abrogated.

I have already endeavoured to show that angular contraction of the knee, whether accompanied by luxation or the contrary, can be readily overcome by the adoption of proper mechanical means. I shall now proceed to the description of such instruments as are employed for the purpose of re-establishing motion, after the joint has been brought into a normal position; since it is necessary to show not only by what apparatuses the limb can best be straightened, but also the means by which it may be most readily retained in its restored position, and by which mobility and natural action may be imparted to the joint.

The simplest of these instruments (Fig. 165) consists of a wooden chair, upon which the patient sits, the thigh being surrounded and fixed tightly to the seat by two broad straps. A padded band, furnished with buckles and straps, is attached to the ankle; a cord which passes over a pulley fixed in the ceiling connecting the hand of the patient with the end of the lower leg. Upon

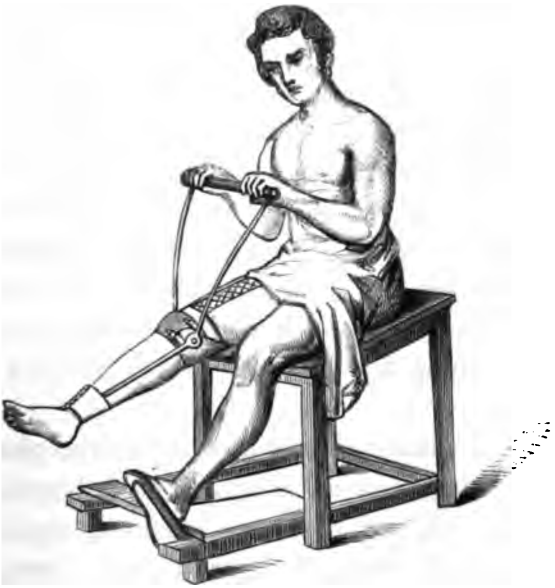
FIG. 165.



pulling this cord the knee is extended, while flexion is obtained partly by the weight of the leg, partly by voluntary effort. In this way an easily regulated motion of the knee-joint is obtained.

The next appliance (Fig. 166) is of a more complex character, its object being to re-establish

FIG. 166.



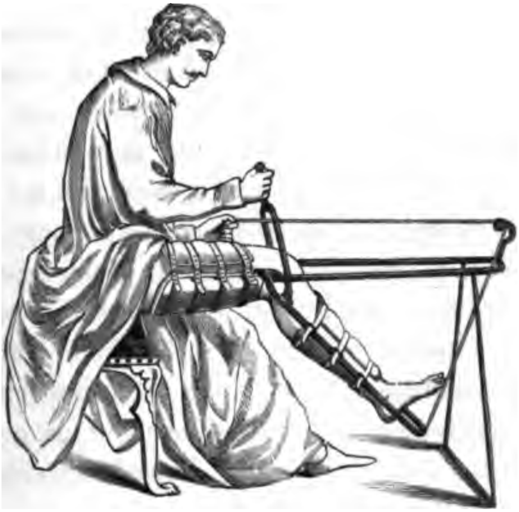
regular and well-sustained flexion and extension, independently of any muscular aid which might be received from the flexors of the patient. This apparatus consists of a strong wooden seat, fixed on a square frame which rests upon the ground. A padded thigh-trough, with two pivots at its inferior extremity (opposite to the centre of the knee-joint), is firmly attached to that part of the seat on which the patient's body rests. To these pivots, and rotating around them, a double lateral lever is fixed, the upper extremity of which ends in a cross bar, acted upon by the hands; whilst the lower end forms an ankle-trough, to which the patient's leg is firmly secured. Upon pressing the cross bar forwards with the hands, the knee is flexed, while by drawing it towards the body the leg is again extended; thus producing the action which is of all others the one most essential for the restoration of mobility to the joint.

In order that the patient may have the power of exercising considerable force (if needed) against the hand-rail, and, thence, on the knee, the foot of the sound limb rests upon a small piece of board, which is secured to the front of the frame, and has also the effect of steadying the patient's body while the apparatus is in motion. The pelvis is likewise held firmly to the seat of the apparatus, by a well-padded strap passing directly across the lower part of the abdomen, and fastened securely to the opposite side. As the thigh and pelvis are thus held firmly to the seat, a fixed point is afforded against which the lateral levers may act. These are so curved that the limb is flexed to a right angle when their upper arm is thrust forwards, and extended to a straight line when it is drawn back to the body; the reason of this being, that the lower arm, or portion anterior to the centre of motion, forms the radius of a circle described from the knee-joint as a centre, to the heel as a point in the periphery; therefore, as this lower arm is but a continuation of the upper one, the space traversed by the former is represented in the latter by a distance proportionate to the longitudinal difference between the levers; thus, if the radius of the lower lever be eighteen inches, that of the upper six,—the lower will move through three inches of space to every one traversed by the upper; it therefore follows, that if the arms of the lever are carefully proportioned, as regards length, a great range of motion may be gained for the knee without imposing much labour on the patient.

Perfect mobility of the joint may be obtained with either of the instruments which I have described; and unless some such apparatus be used, the knee will, in all probability, RECONTRACT. In order to prevent this, when the knee is not exercised in the fashion described, the patient usually wears an instrument passing from the pelvis to the ground, and furnished with hinge-joints at the hip, knee, and ankle. There is a small screw at the knee-joint of this instrument, by which the action of the articulation can be arrested; since it is often desirable that the knee should be kept fixed during the greater portion of the day, and movement be permitted only when the patient can give undivided attention to locomotion.

Bonnet has devised a very ingenious, but somewhat more complex, piece of mechanism for flexion and extension of the knee. In the following figure (Fig. 167) the apparatus is shown as applied. It is formed of two parts articulated together, of which one embraces the thigh, the other the leg. A support maintains the mechanism at a sufficient elevation for use, and gives

FIG. 167.



attachment to a pulley. A cord, fastened to the lowest part of the leg-piece, passes through the pulley to the hand of the patient and serves to extend the leg. A handle fixed to the upper part of the leg-piece serves equally for extension or flexion. The whole apparatus is constructed of steel, padded where requisite. A graduated scale may be attached to the point of junction between the thigh- and leg-pieces, to regulate the degree of extension or flexion.

Another of the deformities of the knee, for which mechanical appliances are used, is known as *lateral displacement of the head of the tibia in an outward direction.* The apparatus by which this can be overcome consists of a lateral metal stem, attached to the leg by thigh- and calf-troughs, and fitted with two rack-and-pinion centres; one of which corresponds with the axis of the knee-joint, the other moving rectangularly above it. The inferior extremity of the leg-stem is fixed to a laced boot, which gives the instrument a perfect control over the limb, both in lateral and anterior extension. In form this instrument resembles that depicted at page 440, with the addition of a rack, intended to restore the tibia to the vertical plane.

Vertical rotation of the tibia occasionally complicates cases of "knee-contraction. This can be removed mechanically, by placing a *horizontal* rack-and-pinion joint *immediately below* the extending centre of an instrument similar to that shown at page 440. The reason why it must be below the ratchet which governs the extension of the limb, is, that the femoral part of the appliance then becomes a fixed point for tibial rotation; this arrangement being in accordance with the anatomical conditions observed, when the position of the tibia has been changed as regards its longitudinal axis. It is not necessary to give an engraving of this instrument, for it is a mere modification of that just mentioned. As regards the two instruments last described—the one for lateral displacement, the other for vertical rotation of the tibia—it is highly important that the relative positions held by that ratchet centre which is especially intended for the correction of either deformity should be carefully observed. In the first instrument, the ratchet is placed *above*, in the second, *below* the extending joint; for if these conditions were neglected, or reversed, the instrument would be rendered entirely useless. I have seen several instruments in which the points just stated have been ignored, the non-success following their application fully illustrating the necessity of paying great attention to these ratchets.

Curvature of the femur anteriorly is sometimes met with in combination with contraction of the knee; but, unhappily, the mechanical treatment employed for this deformity has been so very unsuccessful in producing beneficial results, as to render the mechanism adopted worthy only of a brief notice. The instrument usually adopted consists of a lateral stem, attached below to the foot, and above to a pelvic band. Hinged joints, opposite to the knee, ankle, and hip, correspond with the actions of these several articulations. That at the hip is furnished with a stop, which, whilst allowing the joint to be bent freely in an anterior direction, opposes any tendency which may exist for posterior flexion. A padded metal plate passes over the front of the femur, at the centre of the lateral stem which extends between the hip and knee; while a strong steel plate, covering the gluteal region at the back of the pelvic band, produces some little resistance, by its lower edge, against the posterior surface of the upper third of the femur. A small padded metal band likewise passes over the back of the lower third of the thigh, just above the condyles. The mechanical action sought to be induced by this contrivance, tends to diminish the arc of femoral curvature, by exercising pressure against its anterior surface, and extending its extremities. The use of the apparatus, however, is rarely attended with benefit, as the *necessary* motion of the hip-joint greatly diminishes, even if it does not entirely nullify the pressure of the gluteal plate.

3. *Bowed or Bandied Legs.*—Few distortions

are more worthy of attention at the hands of those who are professionally compelled to consider what influences the mechanical conditions of one class of deformities will be likely to exert in the production of others than bowed or bandied legs. Thus, an excurvation of the tibia may, if neglected, lead to a loosening of the ligamentous attachments of the knee-joint, disturbance of the functions of the hip-joint, or even deflection of the spinal column.*

The direction assumed by a curvature of the tibia may be lateral, anterior, or a combination of both the one and the other; and it not unfrequently happens that a simple instance of either of the two former conditions is converted into a severe one of the latter, simply through a neglect of the most ordinary mechanical precautions.

Although a consideration of the pathological causes of bowed legs is foreign to the subject of this work, yet it may be well to recall the fact that this deformity is primarily due to a softening of the bones, the result of a change in the chemical proportions of the component ingredients of the osseous structures, a diminution, in fact, of the earthy matters. The deformity is referable to the mechanical results arising from this softened condition of the bones—the legs being unable to bear the weight of the body, unaided by artificial assistance. When this extraneous help is withheld, the bones become curved on their long axes; therefore, all mechanical treatment should aim, firstly, at supplying the outer aid; secondly, at restoring the arched bone to its normal condition.

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* Bishop 'On Deformities,' p. 247.

There are two methods upon which this is sought to be accomplished. One seeks for an extension of the extremities of the curve, and depression of its arc, by supplying an artificial base on the side of the concavity, and gradually compelling the leg to become parallel with it; the other, by an application of a straight line to the vertex, or highest point of the arc, endeavours to draw the extremities towards the line until the limb has been brought into a normal shape.* The latter plan is rarely followed—in fact, it is very doubtful whether it can ever have succeeded; firstly, because it is extremely difficult to keep any straight surface applied to the vertex of the curve; secondly, because it is almost certain that such a mode of treatment, if attempted, would be defeated by the production of abrasions. The plan generally pursued in the mechanical treatment of these deformities is therefore in conformity with the former of these two methods, and the instruments are for this reason commonly constructed as follows:—The simplest (Fig. 168) consists of a padded

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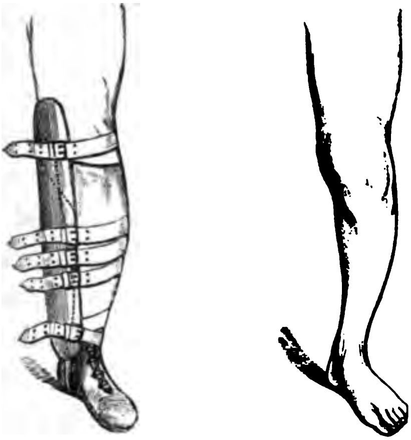
* Little, p. 32.

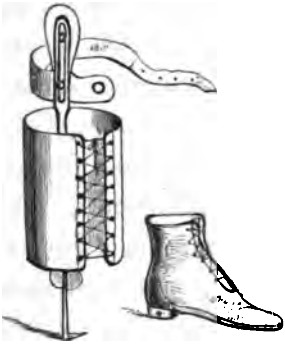
FIG. 168.



piece of wood, placed on the inner side of the leg, and extending from the internal malleolus to a point just above the internal femoral condyle; it is therefore *a base* opposed to the convexity of the curve. A long strap of webbing is passed several times round the leg, so as to embrace both splint and tibia, which, by compression, tends to diminish the arc of curvature.

This splint acts imperfectly unless secured to the heel of the patient's foot by a metal socket, which has the effect of preventing the splint sliding round the leg—a thing which will happen in spite of the greatest care, unless the boot and splint are mutually connected. For this purpose, a small piece of metal is fixed to the lower edge of the splint, which is inserted by a tubular socket into the heel of the boot. When the case for treatment is but a slight one, the apparatus described will do all that is required; but if anterior yielding is superadded to lateral deflection, a more complex apparatus will be requisite. For this purpose I usually recommend an instrument (Fig. 169) which is composed of a slight steel stem, attached to the boot by a tubular socket, and at the upper extremity of which is a padded plate receiving the resistance offered by the head of the tibia, whilst a small cushion, which rests against the internal

FIG. 169.

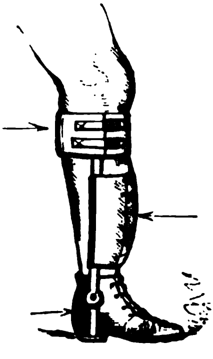


malleolus, forms a point of support to the lower end of the curve. A piece of bent wire, conformed to the quadrilateral outline of the back part of the leg, is attached to the leg-stem at its posterior margin. The whole is completed by a strong leathern bandage, which, starting from the leg-stem, passes around the back part of the instrument over the arc of curvature, when it again rejoins the stem, thus obtaining a circular grasp of the leg. The leathern bandage is closed by a long lace. The action of this apparatus is peculiar: as there are two distinct planes of curvature—one lateral, the other anterior—it is important that both should be acted upon simultaneously; and this is accomplished in the following manner:—The extremities of the lateral curves are opposed by the ankle- and knee-pads, whilst the distance at which the wire calf-piece is placed from the posterior surface of the leg necessarily induces a pressure of the anterior arc backwards the instant that the leathern bandage becomes tightened. So effective is this form of instrument, that the arcs of curvature may be even seen diminishing as the lacing becomes tightened; evidence of this being afforded by the diminution of space between the lateral leg-stem and the posterior calf-piece.

Sometimes, however, the anterior curvature will be so excessive as to defy all attempts at overcoming the distortion by means of this apparatus. In such a case, the instrument just described must be modified by the substitution of a thin metal trough, perforated by four slits in lieu of the wire calf-piece. Through these apertures two webbing straps pass, one above the vertex of the anterior curvature, the other below it; and, as they are attached to the troughs by buckles and straps, they act directly backwards. A small stop-joint is arranged opposite to the internal malleolus, which prevents the unnatural uplifting of the toes, otherwise likely to be produced by the exercise of pressure against the front of the tibia. Instead of fitting into a tubular socket in the heel, the leg-stem is firmly attached to the boot. When this instrument is applied, the two straps and laced leathern bandage are tightened, the former producing pressure against the anterior, the latter against the lateral arc, whilst the metal side-stem supplies a base, at the same time strengthening and attaching the whole.

There is another description of appliance (Fig. 170) which I have made use of in cases of severe

FIG. 170.



anterior curvature, unaccompanied by much lateral deflexion. It is composed of two perpendicular stems, jointed opposite to the ankle, and furnished with a *lacing* leathern band, which passes across the front of the leg and is then reflected back again around the lateral stems. The leg-stems terminate above by a metal band which joins them posteriorly, and below is a laced boot. On application, and tightening of the leathern bandage, the head of the tibia receives the pressure of the upper metal band at its posterior surface, while the heel of the boot serves for a second point of resistance, so that the more the laced band is tightened over the arc of curvature, the greater will be the depression of its transverse axis, with a corresponding expansion at the extremities.

As every kind of tibial deformity may be successfully treated with these appliances, there is no necessity for my describing others, which are mere modifications in structure of one or the other of the plans just detailed.

6. *Club-Foot* (*Talipes*).—There are four primary varieties of club-foot, viz.,

A. *Talipes valgus.*
B. *Talipes equinus.*

C. *Talipes varus.*
D. *Talipes calcaneus.*

Two or more of these varieties may exist together, forming sub-varieties.

A. *Talipes valgus*, or lateral yielding of the ankle-joint outwards, combined with extension, and sometimes *obliteration* of the arches which compose the plantar surface or sole of the foot, is among the most common of those deformities of the lower extremity which call for mechanical treatment.

Talipes valgus occurs with three different degrees of severity, each of which is treated by means of a distinct apparatus, the mechanical actions being based upon the peculiar anatomical conditions present in the variety under consideration.

The first, and least severe form of valgus, is that in which the inner ankle is laterally inverted, with slight extension of the plantar arch. This deformity is principally met with in children, and is commonly termed "in-ankle." The appliance used in cases of this description consists of a leathern boot laced to the toes, rendered stiff on the inner side, and furnished with an india-rubber pad shaped like the quarter of an orange. The convexity of this pad being opposed to the depressed plantar arch, forms a kind of stay or buttress, thus tending to restore the arch to its original form, and strengthening the plantar ligaments at the same time. The elasticity of the material prevents abrasion of the skin, even where the scaphoid tuberosity is unusually prominent. In addition to the support which the pad gives to the flattened instep, the stiffening at the lateral margin of the boot upholds the inner ankle, and aids in giving a firm point of resistance to the pad, while it also prevents abduction, or out-turning of the foot. A triangular strap fixed to the external surface of the boot, and beneath the inner malleolus, affords support in place of the deltoid ligament—generally weakened in these cases.

Another plan of mechanical treatment is occasionally adopted in slight cases—viz., the insertion of an arched metal plate between the soles of the boot; but this is objectionable on account of the unyielding nature of the force brought to bear against the depressed plantar surface.

In every case it should first be decided whether vision of the tendons be advantageous, or the ntrary. In ordinary cases of valgus, there can but little doubt that as the peronei muscles d in raising the external margin of the foot, vision of their tendons will often materially ssen the period of mechanical treatment, by stantly removing one of the main obstacles; vertheless, a large proportion of cases recover ithout operation, and the patient suffers no her inconvenience than that of wearing a pad ithin the boot. Fixing an elliptical piece of ather externally to the inner margin of the el, improves the appliance greatly, as by ving obliquity to the tread, in a direction posite to that in which the arch is depressed, greatly facilitates the action both of pad and iffener.

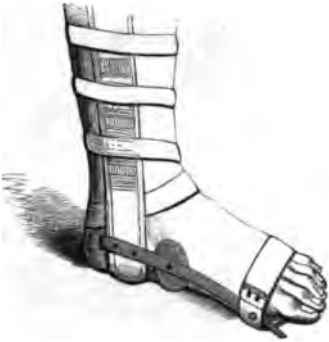
In the form of valgus just noticed, the full tent of the plantar depression is best exhiited, when the weight of the patient falls on e foot, as in standing. When tenotomy is sorted to, other forms of apparatus must of urse be employed; these, however, will be scribed with the contrivances used for the eatment of this deformity when of a more ecided character.

The second degree of talipes valgus is characterised by entire obliteration of the plantar arch, uplifting of the external margin of the foot, and considerable abduction of its anterior two-thirds. Obliteration of the arch is said to be referable to a relaxation of certain muscles and ligaments at the sole of the foot, especially of the great cubo-astragaloid ligament; uplifting of the margin, to contraction of those muscles which raise and rotate the foot outwardly; and abduction of the anterior two-thirds, to downward displacement of the scaphoid bone, entailing a separation of its tuberosity from the astragalus.

So many forms of apparatus are employed for the treatment of valgus in the second degree, that without unduly extending this work it would be impracticable to describe more than those most generally adopted.

The first (Fig. 171) to be noted, consists of a wooden splint, having at its inferior extremity a horizontal spring, furnished with a sliding oval pad. When adjusted, the splint is so secured by a roller bandage to the inner side of the leg, that the pad rests against the scaphoid tuberosity. A webbing strap is then passed around the toes, and drawn to the spring by means of a

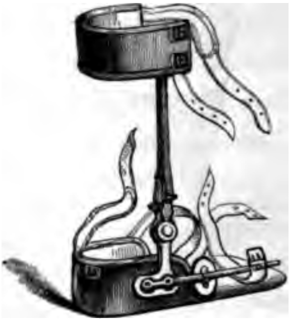
FIG. 171.



buckle, the mechanical result being, that the pad becomes a fulcrum for the uplifting of the plantar arch, while the spring acts as a lever in overcoming both the muscular traction and abduction of the foot. It will be seen that, in this simple form of apparatus, there is a manifest deficiency of one condition—viz., power of changing the obliquity of the sole, which, both in valgus and varus, offers a great obstacle to the restoration of the limb to its normal condition. This apparatus is therefore ill adapted for cases in which there is *very marked* obliquity of the metatarsus.

Another apparatus (Fig. 172) is thus constructed:—A padded metal shoe receives the

FIG. 172.



foot, a perpendicular stem being fixed on its inner margin, just below the internal malleolus, with a tangential screw-joint opposite to the axis of the malleolus. Above this point, at right angles to its plane of direction another screw is adapted; a metal bar, horizontal with the foot, and secured to the inner heel-piece, gives attachment to a sliding pad, and from the end of this bar three metal studs project, which serve to fix a webbing toe-strap. When applied to the leg, the foot is kept *in situ* by three straps passing over the instep, one of which springs from the back of the heel-piece, and the lateral stem is secured to the leg by a padded calf trough; the toes are likewise kept from abduct-ing by the webbing strap which belongs to the horizontal stem.

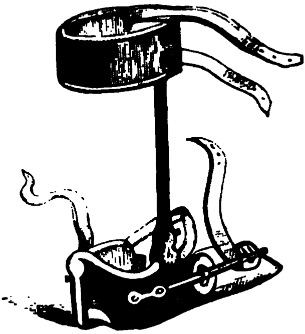
The mechanical action induced on bringing the apparatus into play is, 1st, an uplifting of the plantar arch; 2ndly, a depression of its outer margin with adduction of the toes, which is accomplished as follows:—When the toe-strap is drawn tightly towards the horizontal bar, the sliding pad is brought powerfully into contact with the projecting scaphoid bone, and a tendency to an uplifting of the arch is at once established; the foot-piece must then be extended by moving the ankle-screw in such a direction that the toes may point downwards. It next becomes necessary to turn the upper tangential screw so that the sole of the foot-piece may be depressed at its external margin. The united result of these several actions is, an uplifting of the arch of the foot, adduction of the toes, and a decrease of obliquity in the sole; finally, the foot must be brought into its normal position by reversing the action of the ankle-screw.

The apparatus just described would not be applicable, save in cases where tenotomy has been performed, *prior to its adoption.*

A third apparatus is one in which springs are employed in place of stiff metallic bars, the mechanical actions, nevertheless, being identical with the preceding.*

A fourth kind (Fig. 173) is thus constructed:

FIG. 173.



—The foot is received by a metal shoe-piece, and a horizontal toe-bar, with a webbing-strap, controls the toes; but there is a peculiar deviation from the ordinary construction in the leg-stem, which, instead of being placed at the inner margin of the heel-piece, is fixed to its posterior border, and surmounted, at a point corresponding with the long axis of the foot, by a tangential screw; the other extremity carrying the usual tangential screw ankle-joint, which thus forms part of the leg-stem, as in the second apparatus. The mechanical power of an instrument thus constructed is very great, as it is able, by a special action, to depress the external margin of the foot and upraise the arch simultaneously—an advantage which cannot be overrated. This action may be thus explained:—

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* One great objection to metallic spring power being used in these cases is the impossibility of regulating, with anything approaching to certainty, the force employed; hence, abrasion is much more likely to result than when the tangential screw is adopted.

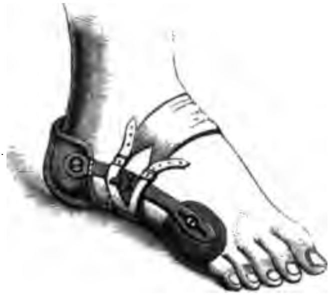
When the foot is secured in the metal shoe-piece, and the toe-strap tightened, there is pressure against the scaphoid bone, as in the other mechanical appliances described; but when the screw is applied to the posterior joint, the entire foot is rotated around its major axis, thus inducing, at one and the same time, an uplifting of the arch, and depression of the external margin.

The principles laid down as being essential for the mechanical treatment of valgus, are more strictly adhered to in this than in any other instrument; for the posterior screw is in relation with that point in the great tarso-metatarsal joint, around which the anterior two-thirds of the foot rotates while the external margin of the metatarsus is being uplifted; the horizontal bar being likewise always brought into the same plane as the metatarsus, drawing it downwards and outwards whilst in action. The tangential ankle-screw, also, helps to uplift the arch in the restoration of the foot to its normal position (at right angles with the leg), by depressing its anterior part. This is an invaluable instrument. The credit of its invention is due to Dr. Laugard, of Hamburgh.

Valgus of the third degree is of very rare occurrence, since pain, an invariable concomitant of valgus in the earlier stages of the second degree, indicates the necessity of treatment, and thus prevents a neglect of the deformity. When, however, this very severe form comes under surgical care, the apparatus employed for its reduction is generally similar to the one last described, with the addition of a ratchet-jointed lever and pad fixed to the internal margin of the heel-piece, the mechanical "set" of which, being in a more oblique direction than that of the toe-bar, becomes a powerful fulcrum for the uplifting of the scaphoid, with adduction of the front of the foot. This form of lever, aided by the posterior screw, is calculated to be highly beneficial in severe valgus. Occasionally, however, even this instrument is inapplicable by reason of an unusually large amount of abduction. The mechanical treatment must then be divided into two stages.

For the first, it is necessary to use a slight stem of steel with a free joint at the ankle, which is attached to the leg by an ordinary calf-band, and fixed to it (in contradistinction to all other instruments for valgus), on the outer side of the leg (Fig. 174), hinged perpendicularly at its point of attachment, and having a small padded plate resting against the os calcis. At the centre of this lever, in correspondence with a depres-

Fig. 174.



sion situated just above the cuboid bone, there is placed a ratchet joint, and at its digital end a padded plate, which rests against the whole length of the first metatarsal bone. From the ratchet's centre, a strong webbing passes over the dorsum of the foot, embracing the scaphoid tuberosity.

Upon bringing this apparatus into action, the first point of resistance is at the scaphoid, the next at the metatarsus and os calcis. Hence, the lever forms the base of a triangle, at the apex of which is the projecting scaphoid, and, as the lines of mechanical power act in direct antagonism to the perverting forces, the metatarsus is forced downwards, and the scaphoid raised; the usual action being thus reversed, yet with the same result as is obtained with the other appliances, for with them the metatarsus is *drawn downwards*, whilst by this it is *thrust downwards*.

In the second stage of treatment, it is simply requisite to employ the ordinary apparatus used for valgus of the second degree.

The importance of tenotomy is so widely acknowledged, and its adoption so general, that it is scarcely necessary to observe, that all the instruments which I have described as applicable in valgus of the second and third degrees, are nearly useless apart from this operation.

In what is commonly termed "flat-foot," a condition of valgus which merely involves a depression of the arch of the foot, proper mechanical appliances alone suffice to restore the lost symmetry.

B. *Talipes equinus.*—This variety of club-foot, popularly known as "horse-heel," the chief anatomical characteristic being a permanent contraction of the tendo Achillis, by which the os calcis —the posterior pier of the plantar arch—is raised to such an extent, as to cause the whole weight of the body to pass through the front of the foot only, thus destroying the natural heel-and-toe action during progression. In a mechanical point of view, talipes equinus is more easily reduced than any other deformity of the foot. The simplicity of the deformity was in all probability the main reason of its having been selected for the earliest attempts of modern orthopædic surgery.

Pure talipes equinus, *i. e.*, equinus unaccompanied by any lateral deflection of the longitudinal axis of the foot, is a rare deformity;

since the moment the base of support given in the normal state by the whole of the foot, is transferred to the metatarso-phalangeal extremities, a tendency arises to contraction inward of the arch of the foot in strong persons (equino-varus), outward, in weak ones (equino-valgus). The following appliances are those most usually employed for the reduction of talipes equinus.

The first is known as "the foot-board of Stromeyer"* (Fig. 175).

It consists of a piece of wood, shaped to the sole of the foot, and secured at the heel-axis to a wooden splint, upon which the back of the leg is kept in position by means of straps. The foot-board is flexed upon the leg by pulleys, so that, when the foot is secured sufficiently firmly to prevent uplifting at the heel, extension of the tendo Achillis necessarily ensues. This contrivance is, nevertheless, very crude, as it entails confinement to bed during the whole period of

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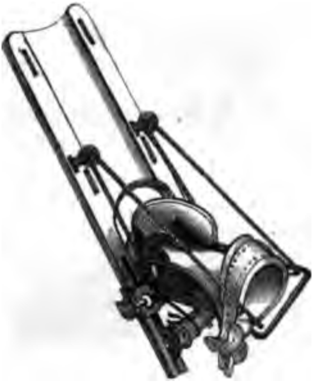
* This form of instrument is rather clumsy: but as it has been advocated in the pages of one of the best works upon Orthopædy, I feel bound to give it insertion amongst other appliances: the drawing is copied from Dr. Little's work.

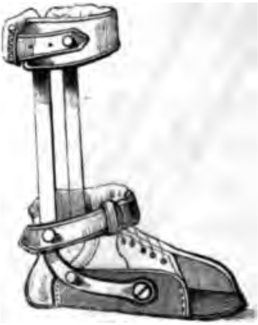
FIG. 175.



treatment, which is extremely irksome to the patient. Moreover, it is decidedly erroneous in action, mechanically speaking, for the centre upon which the foot-board moves, does not coincide with the axis of the malleoli, a point which should be kept strictly in view during the reduction of equinus.

A far better instrument for the cure of this deformity was suggested by Mr. Liston (Fig. 176). This consists of two curved levers, joined at their upper extremity by a padded leg-band. A metal shoe is fixed to their lower ends, rotating between them at the points of junction. A padded strap, passing over the dorsum of the

FIG. 176.



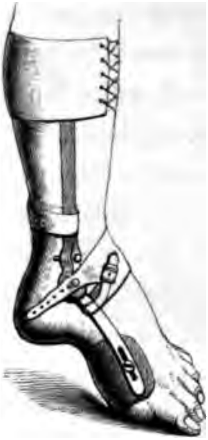
foot from that part of the lateral levers which coincides with the astragalus, becomes a fulcrum, against which the lateral levers act in such a manner as to depress the heel while the toes are uplifted. Mr. Liston called this apparatus a "Lever Instrument," as he rightly conjectured that the leverage of the lateral curved bars would act more directly and simply upon the raised instep in this, than in any more complex contrivance. An important point gained in this apparatus was, that the act of walking facilitated the descent of the heel, by elongating the contracted tendon, whereas, even if walking had been possible with Stromeyer's foot-board, extension of the tendo Achillis would have been prevented, on account of the bodily weight being thrown upon those cords which uplift the toes. In the one apparatus the heel would descend, in the other the toes would be raised.

The principle of action in Mr. Liston's instrument, may be explained by showing that it assumes, as a fixed centre, a point coincident with the metatarso-phalangeal articulation, by moving on which the raised heel is compelled to descend in an arc of the periphery of a circle, the radii of which would be represented by lines passing from the common centre to the extremities of the piers of the antero-posterior arch of the foot.

This appliance has been objected to, on the ground that it exercises little or no control in preventing a too sudden elongation of the tendon. This objection, however, can be easily removed, by fixing a strap and buckle to the heel-piece, by which it may be secured to the calf-band, thereby preventing the depressing force exercised by the instep-strap from being carried out to a greater extent than is considered advisable.

Some time ago I constructed a modified form of this apparatus (Fig. 177) for a severe case of

FIG. 177.



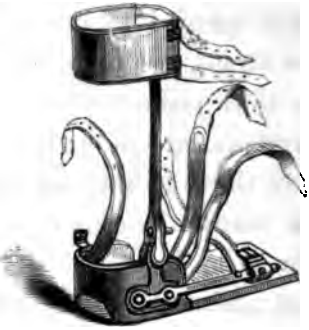
talipes equinus. The case treated was characterised by a remarkable shortening of the plantar arch, with a displacement of the astragalus in an anterior direction. I deviated, in some particulars, from the principles acted upon in the construction of the ordinary instruments. Two curved levers of metal passed downwards on either side of the leg, similar to those used by Mr. Liston. These levers terminated, anteriorly and inferiorly, in a metal plate, which passed under the metatarso-phalangeal articulation. A ratchet-joint was attached to each curve, at a point coincident with the articulation of the astragalus and calcaneus with the cuboid and scaphoid bones.

The foot was secured in this apparatus by means of three straps, two of which passed over the instep, the third just above the ankle.

When the instrument was brought into action, the anterior two thirds of the foot were raised, a process which necessarily caused an elongation of the plantar arch, at the same time that it restored the astragalus to its normal position in relation with the trochlear surface of the tibia. The anterior extremities of the curved levers rotated around the screw-centre, and as the plate which is placed beneath the toes obtained an elevation proportional to the radius passing from the centre-ratchet to the extremity of the lever, an extension of the plantar arch was secured by their united actions.

Another apparatus (Fig. 178), and that which is most generally used in the treatment of talipes equinus, is constructed as follows:—A perpendicular lever, from which a horizontal stem runs along the length of the foot, is fixed to the leg by a calf-band, and attached at its inferior extremity to the external lateral margin of a well-padded metal shoe-piece. In that

FIG. 178.

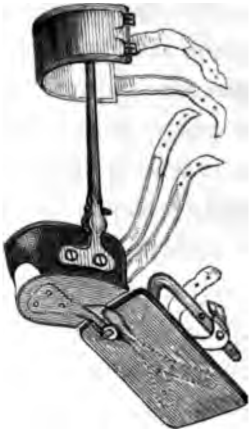


portion of the leg-stem which is opposite to the ankle-joint an axis is placed, governed by a ratchet and screw, while the shoe-piece is bound to the foot by two straps, which pass over the instep, a third surrounding the toes, and securing them firmly against the horizontal foot-stem. Flexion of the foot upon the leg, is induced by the mechanical action of this apparatus. Upon moving the screw at the ankle, the angle made by the foot-piece with the perpendicular lever is rendered less obtuse than that which it held in the original condition of the equinus; and as the foot is secured to the shoe-piece beyond all chance of displacement, any deviation of position in the latter, affects the former in an equal ratio, whilst the tendo Achillis is proportionately extended. This form of instrument is strongly advocated, in consequence of its giving a perfect control over the amount of lengthening which the surgeon may wish to give to the tendo Achillis, since a *too rapid extension* of the "callus," or new plastic matter, which unites the divided ends of the tendon after tenotomy entails an attenuation and consequent weakening of the tendon, which is highly undesirable.

I have purposely abstained from giving any elaborate description of the spring instruments which are occasionally employed in the treatment of equinus, as I do not consider that their mechanical principles are perfect, owing to a probability of a too rapid extension of the tendons. There is no arrangement made in their construction, by which the depression of the heel part of the apparatus may be regulated. Briefly, they resemble the instrument shown above in all respects save one—the substitution of a tempered steel spring, *moving on a free axis below the external malleolus,* in lieu of the stiff perpendicular stem, with a ratchet ankle-joint.

Sometimes, in addition to the elevation of the heel, there is a considerable lessening of the plantar arch. The instrument (Fig. 179) which

Fig. 179.



is best calculated for the counteraction of this complication is thus constructed.

An ordinary foot-piece is divided into two parts, one receiving the heel, the other, the sole of the foot; a ratchet joint, coincident in the direction of its action with that of the mesial line of the foot, uniting these two portions. A horizontal metal bar, carrying a toe-strap, is attached to the external lateral margin of the anterior of the two divisions; whilst the posterior, or heel-piece, has a perpendicular stem, with a ratchet ankle-joint fixed to it. The foot is secured from displacement, on the instrument's being placed in action, by two straps which pass over the dorsum.

When this instrument is to be applied, the ankle ratchet joint should, first of all, be turned, until the apparatus has been made to assume an angle equal to that formed by the heel and leg. The anterior plate of the shoe must then be so depressed, by means of the *plantar*-rack, as to coincide with the line of direction held by that portion of the foot upon which it is intended to act. The toe and instep straps ought now to be drawn tight by means of their several buckles. The mechanical actions called into play, on the due performance of these several steps, are as follows :—

The extension of the ankle-ratchet, coinciding as it does with the centre upon which the calcaneus and astragalus rotate during an uplifting of the heel, necessarily depresses the heel, while it also elongates the contracted tendo Achillis, and, at the same time, uplifts the front of the foot. In this latter action, however, the anterior extremities of the metatarsal bones offer the greatest amount of resistance ; consequently, the abnormally-shaped arch is *raised,* without being *expanded.* This difficulty is got over by the action of the plantar ratchet-joint, which unites the two pieces of the sole-plate. By moving this screw, the longitudinal arch is lengthened, and the entire plantar surface being then acted against, instead of the metatarsal extremities alone, the breadth of the foot is increased; the foot, at the same time, being held in its correct position.

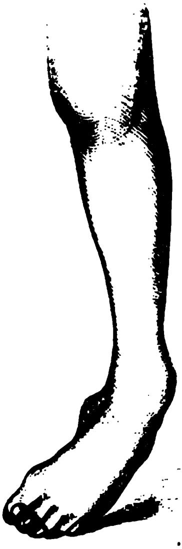
In this way a distortion, such as I have described, may be reduced, without pain or inconvenience to the patient.

c. *Talipes varus.*—This deformity is mainly characterised by an uplifting of the heel, adduction, or turning inwards, of the toes, and consequent sinking of the outer ankle towards the ground, to a greater or less extent (Fig. 180). It is perhaps the most important distortion of the foot, and is the most difficult to treat.

Looking at Talipes varus anatomically, it is seen that the position just described is referable to a displacement of the bones composing the tarsus, or instep.

Surgical writers recognise three degrees of severity of talipes varus:—In the first and

FIG. 180.



slightest, there is inversion of the metatarsus, trifling upraising at the heel, and but little obliquity of the sole, in consequence of persistent contraction of the tibiales posticus et anticus, and the muscles which end in the tendo Achillis. In the second, great adduction of the metatarsus, with considerable oblique displacement of the scaphoid bone around the anterior surface of the astragalus; uplifting of the os calcis, and an arching outwards of the tarsal bones, so that the cuboid becomes remarkably prominent, are the most marked features. In the third, a long maintenance of the foregoing conditions has actually brought about a change of form in the very bones themselves, so that the patient is absolutely compelled to walk, though with great pain, upon the dorsum of the foot.

Prior to a description of the various mechanisms which are necessary for the treatment of these three varieties of varus, it will be well to touch briefly on the relations which some of the tarsal bones bear to the centres around which they play.

In a normal state of the foot, the axis of its motion with the leg is situated in the tibio-tarsal joint (*i.e.* so far as flexion and extension are concerned), the surfaces of which are nearly horizontal—sufficiently so, practically, at all events, for the performance of the various motions of the foot in its mesial plane. The axis of motion on which the external and internal margins of the metatarsus are alternately lifted or depressed, is likewise referable to this point, as is also that of horizontal rotation, though this last is seldom of marked importance. Thus the various motions which *the foot as a whole* is capable of receiving are all dependent upon one common centre of motion in the tibio-tarsal articulation.

The most restricted of the above movements between the foot and leg bones are those in horizontal and lateral directions; it must therefore be evident that, since there is very great lateral displacement in cases of varus, motion must be set up from some other centre, in place of the normal and true one. Now, if in pursuance of this idea, a dissected preparation of a club-foot be examined, considerable yielding of the structures will be found anterior to the astragalus. The lateral movement of the scaphoid upon the head of the astragalus could, indeed, alone account for so great an amount of adduction. Hence is inferred the existence of a centre of motion at some point in that part of the foot in which is situated the articulation of the astragalus and os calcis with the cuboid and scaphoid.

Modern writers on orthopædy bring forward ample evidence in favour of this theory.*

Since an uplifting of the heel deprives the astragalus of a portion of the anterior support hitherto given to it by the scaphoid, the bone is thrust unduly forwards, so as to become prominent upon the dorsum of the foot; advancing at the same time, in such a manner as to obtain a new centre of horizontal movement, apart from, and in front of, that point, which is, in the normal state of things, the common centre of motion in the ankle-joint. By these changes, two of the normal centres of motion are disturbed, a circumstance which renders it necessary that the mechanism intended for the treatment of varus should be devised so as to act in coincidence with the changed direction of action of the deformed foot, by being so constructed that its centres of motion shall be placed at the points of deviation. How this desideratum may be accomplished, will be best shown by giving a detailed description of the principal appliances which have been invented for the cure of the distortion under consideration.

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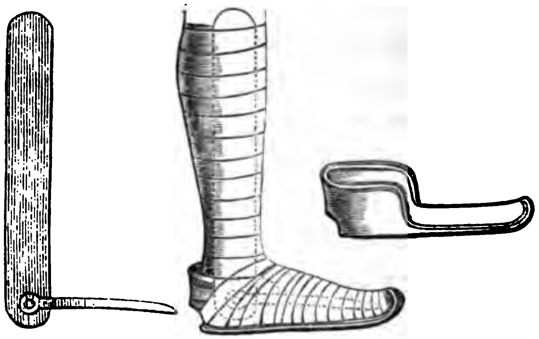
* See Adams's Lectures, *Medical Times*.

I shall commence by describing the plan pursued by Sheldrake (the earliest English writer on the treatment of club-foot), prior to the introduction of tenotomy. His apparatus consists of a padded metal shoe and lateral leg-splint, with a horizontal toe-spring. It is attached as follows:—The deformed foot is carefully bound in the shoe-piece by strips of adhesive plaster, the next step being to secure the side splint to the outer side of the leg, in a similar manner, and the adducted foot is then finally drawn to the shoe. The mechanical action of this appliance is readily intelligible, for upon binding the foot within the shoe-piece, its lateral and inferior arches become extended by the pressure of the strapping on the dorsum of the foot, together with the counter-resistance of the calcis and metatarsus. When securing the side splint, care must be taken to give it a fulcrum against the metallic edge of the shoe-piece, as all chance of abrasion over the cuboid bone is thereby avoided, while at the same time the tendo Achillis may be stretched by slightly varying the angle of the foot-piece. When, last of all, the lateral horizontal toe-spring is brought to bear upon the foot, it compels abduction and flexion, thus gradually restoring the foot to its normal condition.

A small aperture is always left at the back of the heel-piece, in order to see that the heel is fairly down in its proper place.

FIG. 181.



Although this form of apparatus is now superseded by others of greater efficacy, yet it is without doubt safe and certain in attaining the desired object in those cases of infantile varus, to which tenotomy is, for some special reason, considered inapplicable.

In the earlier part of my career, and prior to the general adoption of tenotomy, I have frequently had as many as ten or twelve cases at a time wearing the simple shoe and adhesive plaster as devised by Mr. Sheldrake, and with scarcely any exception all these cases succeeded. The plaster was removed about once a week, the foot washed, a clean splint applied, and the foot rebound without giving the infant the least pain, neither was there any abrasion, as but too frequently results, if the modern appliances are not very carefully watched.

The next kind of appliance used for slight varus consists of a series of padded tin shoes, the angles of which are raised in degree as the cure progresses, until the foot has regained its rectangular position in relation to the leg, and which are attached to the foot by adhesive straps; the object of the treatment being gradually to mould the foot into its true position.*

A third, and highly ingenious appliance, is that termed "the Talipede" (Fig. 182), invented by Mr. Aveling, of Sheffield. The three desiderata, abduction, flexion, and retroversion, are obtained by this piece of mechanism as follows:—Into the interior surface of a metal shoe-piece (A), just below the heel, a circular piece

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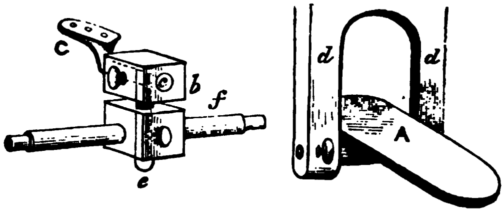
* Little, p. 177.

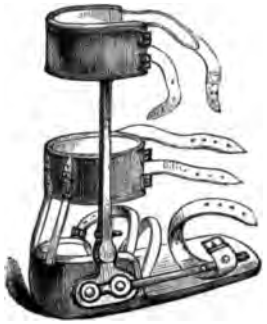
Fig. 182.



of solid metal is riveted (c), which is in turn received into a steel socket; the latter being in connection with a portion of the bar (*f*) which joins two lateral uprights (*d d*) (in which a leg splint, supporting the calf, terminates), by means of a small metal ring on the cylindrical surface of the bar, which, in addition to receiving the socket, can be rotated on its own transverse axis. Thus, the fixing of the socket to the sole-piece allows the inner margin of the foot to be moved in a downward direction, abduction being facilitated by the manner in which the socket is received in the metal ring; whilst the cylindrical form of the connecting bar enables the ring to turn on its surface, by which means every advantage is afforded for obtaining the required amount of depression at the heel. In order that the foot may be maintained in the desired positions, each point of motion can be checked at will, by simply tightening a small thumb-screw; and in this way the foot may gradually be brought into a correct form, without abrading the cuticle or paining the patient, while the instrument is so adaptable that it can be fixed at any angle which the foot under treatment may have assumed. I entertain a very high opinion of this apparatus, believing that, for simplicity of construction and ease in management, it is as good as any yet employed. It can be successfully applied to every condition of talipes.

The instrument now about to be described, is more frequently used than any other at the Royal Orthopædic Hospital (Fig. 183). It con-

Fig. 183.



sists of a padded shoe, into which the foot is strapped. At the external margin of the shoe, close to the heel-piece, a perpendicular leg-stem is fixed, containing a rack-and-pinion joint, coincident with the ankle-joint. A metal stem passes along the external margin of the foot, having at its extremity a rather broad strap, by which the toes are surrounded.

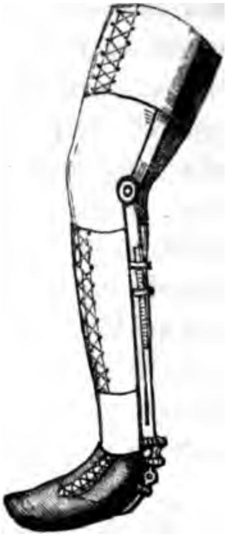
This instrument is a modification of Scarpa's shoe, and is thus applied:—The ratchet-screw is first placed at such an angle as will allow the leg-stem and foot-piece to agree in direction with the corresponding parts in the deformed limb; the heel is then placed firmly in the recess intended for its reception, where it is secured by two padded straps, which pass over the instep. The ankle-band is now fastened round the leg, just above the malleoli, and beneath the perpendicular stem, thus forming a cylindrical strap, which restrains the heel so effectually that it cannot rise perpendicularly in the shoe, whilst at the same time it aids the two instep straps in obtaining a firm hold upon the foot. Proceeding with the adjustment, the toe-strap at the extremity of the horizontal stem is next passed around the toes, taking care to pass it over the toes only, so as to avoid falling into a blunder of occasional occurrence—viz., passing it round the shoe-plate as well as the toes, a procedure which negatives the action sought. Finally, the operation is completed by fastening the calf-band, and thereby firmly attaching the entire apparatus to the leg.

To bring this instrument into action, the toe-strap must be gradually tightened to remove the adduction, and the ankle-screw carefully turned until the heel is brought slightly downwards. By doing this every two days for about six weeks, the foot can be gently brought into its normal position.

There is one great objection to this modification of Scarpa's appliance, which is, that the fulcrum by which the tarsal arch is opened out is obtained by pressure against the cuboid bone, the cuticle over which will, unless the most vigilant precautions are taken, most probably be abraded; an untoward event, which necessarily retards the progress of the cure for so long a period as the wound may remain unhealed.

Dr. Langaard, the celebrated orthopædic mechanist of Hamburg, has invented the following instrument (Fig. 184). An ordinary

FIG. 184.



laced boot, stiffened on the inner side, especially at the heel, is fitted with a steel outside lateral stem, containing a rack-and-pinion centre just below the external malleolus, and two hinges (acting laterally), which are placed above it, at about two inches apart from each other. The upper end of this leg-stem terminates in a perforated lip. Thus much for the lower portion of the apparatus. The upper consists of a padded thigh-band and calf-trough, connected by an external stem, which is jointed at the knee. A perpendicular screw is fixed to the outer side of the calf-trough, the lower end of which enters the perforated lip, already alluded to as forming the upper end of the lower division of the apparatus.

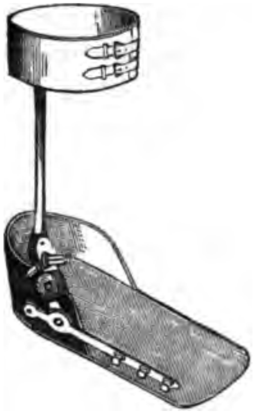
In applying this instrument, the foot must first be firmly laced within the boot, the calf- and thigh-troughs being then placed in their respective places on the leg; a position which, since the lower part of the apparatus is furnished with two lateral hinges, permits the external stem to conform itself readily to the arc which is formed by the tibial and cuboidal surfaces. The perpendicular screw is then gradually turned in such a direction as will induce an upward traction by the ankle-stem; the result of this being that, as the stem is fixed to the boot, and the boot to the foot, this screw-action exerts an immediate depressing influence upon the internal plantar margin of the foot, lessening the external arc of the deformity, by diminishing the length of the metallic superficies with which it is enveloped; the deformity is thus reduced to a condition of equinus. The rack-and-pinion centre, at first placed *beneath* the ankle-joint, but now brought up so as to coincide with its axis of motion, will enable the operator to elevate the foot, while he at the same time depresses the heel, and in this manner restore the limb to a natural shape.

This apparatus seems to be based upon the opinion held by some anatomists, that there is a mechanical centre at that point in the tarsus where the astragalus, calcaneus, cuboid, and navicular bones meet, and around which the anterior portion of the foot rotates longitudinally in the formation of varus. At first sight it would appear that the instrument must act upon all the limb which is situated below its tibial extremity; but as the astragalus is firmly locked within the trochlea formed by the ends of the tibia and fibula, the obliquity of the sole of the foot in varus depends more probably upon lateral inversion, or adduction of the anterior two thirds, accompanied by slight axial rotation. It is frequently suggested that obliquity of the plantar surface may be produced solely by the combined extending and adducting actions, without the least longitudinal rotation; the argument being, that the matatarsus is primarily oblique from the very shape of the individual component bones of the tarsus, with which it is articulated, and that during the formation of varus the foot is at first extended, then drawn laterally inwards by muscular force, the metatarsus, in this latter process, simply moving in its plane of relation with the component bones of the tarsus, which, being originally oblique as compared with the horizontal axis of the malleolus, compels the foot to move in a latero-superior direction. Opposed to this opinion, mechanically speaking, is the consideration, that if the position of the metatarsus be held to account for the uplifting of the inner plantar margin in varus, how is it that lateral movement of the normal foot inwards does not induce uplifting of the plantar arch to a far greater extent than is actually produced? It must therefore be presumed that there *is* slight axial rotation between the scaphoid and astragalus during the formation of club-foot.

One great argument in favour of the rotative theory may be drawn from the frequency with which metatarsal obliquity is found to remain, after the equinus has been reduced, and the foot abducted to a considerable extent; the said obliquity necessitating the employment of powerful pressure upon the dorsal surface of the foot, before the deformity can be entirely removed. The apparatus used to effect this is, technically, called a "clamp," consisting simply of a strong piece of metal, which is arched over the instep, and fixed to the sole-plate of a Scarpa's shoe; a pad, governed by a perpendicular screw, being attached to its upper extremity. The firm and continued pressure of this will gradually depress and extend the plantar arches.

In severe cases of obliquity of the foot, another form of instrument is employed, having a rack-and-pinion joint, acting, at right angles, to that at the ankle-joint, fixed in the leg-stem, just above the external malleolus (Fig. 185). Although intended to aid in overcoming the obliquity of the sole of the foot, it is nevertheless ill calculated for the furtherance of this object, in common with many other analogous instruments, because, upon bringing the lateral rack into action, a tendency to inversion of the upper border of the heel-piece, just below the external ankle, being at once set up, great pressure against the os calcis is produced, and this without the gain of any marked change for the better in the torsional uplifting of the inner border of the metatarsus (due, probably, to rota-

FIG. 185.



tion at the astragalo-scaphoid articulation). Nevertheless, there is this advantage about this instrument, "that it enables the shoe-piece to be more accurately moulded to the foot than it could be in any other form of instrument;" and since much of the plantar obliquity subsides when the anterior part of the foot is drawn outwards, we get a negative benefit from the circumstance that the rack-action just mentioned diminishes the pressure exerted by the heel-piece, while in action, against the external lateral surface of the heel and ankle—and *unequal* pressure is the chief point of complaint in *all* modifications of Scarpa's shoe.

I would in this place enter upon an analysis of the various motions which arise during the progress of talipes varus, from its earliest symptoms to the fully developed stage, so as to lead to the recognition of a *general centre of distortion*, with reference to which centre, the attempts at mechanical restoration should be carried out. I would, if possible, determine the actual situation of that centre around which the osseous structures are grouped in equino-varus. The solution of this question had not (to my knowledge at least) been attempted before the appearance of the first part of my work on 'Deformities.'*

Efforts had, however, been made, successfully, to relieve club-foot by an instrument, the mechanical action of which was based upon a theory, that a transverse tibio-tarsal joint is formed during the progress of the deformity, and that, to ensure success, the treatment should consequently be divided into two stages, viz. one for the reduction of the varus, the other for that of the equinus. So widely has this theory now been adopted, that it is customary, in cases which need operative assistance, to defer the section of the tendo-Achillis until all lateral adduction has been removed by the division of the anterior and posterior tibial muscles, and the foot has been mechanically abducted by means of a "Scarpa's" shoe. If, however, I am right in conjecturing that the one common centre of motion *can* be accurately determined, the necessity for dividing the treatment of club-foot into two stages is removed.

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* 'On the Mechanical Appliances necessary for the Treatment of Deformities,' p. 77. London, 1858.

I have prepared four diagrams, with the view of showing those centres which are set up in the foot during the formation of equino-varus, and shall endeavour to indicate, by inference, how valuable an apparatus that would be which should coincide in its arrangement with the natural law, and restore the foot to its pristine state by means of actions proceeding from one centre only. It must be remembered, though, that the axes of separate motions may be more or less approximated in various individuals; still, the establishment of the common centre is not in the least degree affected by this circumstance, it is simply necessary to make such allowances for trifling variations as each case may seem to demand.

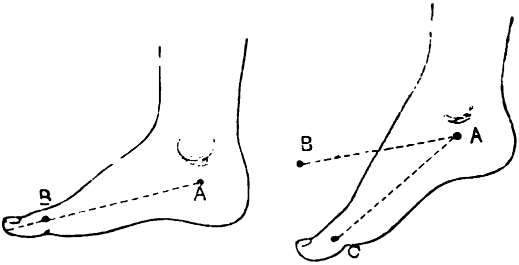
The formation of equino-varus being mainly referable to the contraction of those muscles which extend and adduct—viz. the gastrocnemius, soleus, and tibiales, it is indisputable that these must exercise their power around some special point, as otherwise they would mutually antagonise each other, and a deformity could not be set up.

On examining the direction assumed by the osseous structures of a severe case of club-foot, it will be found that, in addition to that self-evident centre, around which the foot moved during its extension and subsequent condition of equinus, there must have been another centre from which the displacement of the scaphoid, latero-superiorly around the articulating surface of the astragalus, proceeded.

When measuring the radii of motion, with a view of discovering where this axis lies, it is necessary to take some common point in the foot, sufficiently distant to be easily demonstrated in its relations with other centres, and yet so firmly established as to be but slightly influenced, as regards its distance from the assumed centre, by any positional change of the various bones included in the circumference of the circle in which the radients of motion lie. I have accordingly selected the first metatarso-phalangeal joint, as a fixed point readily demonstrable in all stages of club-foot. Having taken this as a fixed point in the periphery of the circle formed by the radii of motion from the common centre, I would direct attention to the following diagrams. Figs. 188 and 189 are to be considered as supplementary, and intended solely to elucidate the correspondence of the structural form of the foot with its mechanical motions.

In Fig. 186, intended to show the direction taken by the foot during the formation of equinus, let A be the malleolar axis, B the first metatarso-phalangeal joint—which is simply selected as a point which bears relation, definitely, with the

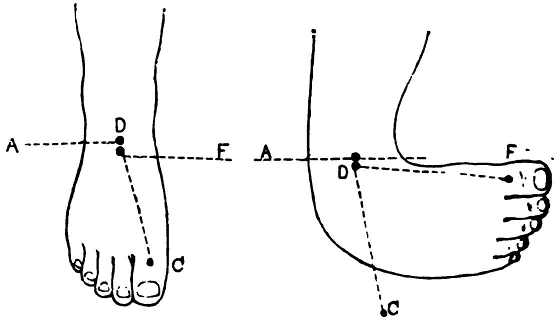
FIG. 186.



several centres in the foot. It will be seen that at whatever angle the foot may be extended upon the leg, the lines A B, A C, will be equal. That is to say, B and C are each points in the circumference of a circle of which A is the centre, and therefore equidistant from A—therefore A is the axis of motion.

In Fig. 187, which represents the direction assumed by the foot during the formation of varus, let D be the astragalo-scaphoid articulation, and C the metatarso-phalangeal, at whatever angle the foot may be abducted, the line D C shall be equal to the line D F—therefore D is the axis of motion in the formation of varus.

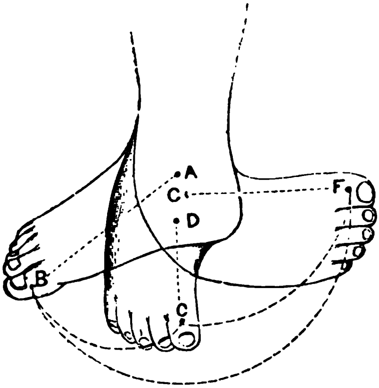
FIG. 187.



Thus, in the formation of equino-varus, the metatarso-phalangeal articulation passes by two distinct planes of motion, from B to C, and from C to F.

Now, instead of moving the point B, first to C, and then to F (as in Figs. 186 and 187), it can be made to move from B to F in a direct line, as may be seen in Fig. 188.

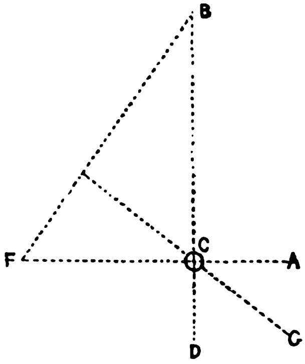
FIG. 188.



Let G be an established point between the centres A D, and equidistant from each, so that G A shall equal G D; G will then partake of the character of both centres, and thus become the common axis around which B will move in its progress to F, and the arc B F will be the line of direction taken by B in its passage to F. This may be better understood by a reference to Fig. 189.

Let A F be the malleolar, and B D the scaphoidal axis, F representing the metatarso-phalangeal articulation. Instead of moving the point F first round the scaphoidal axis B D, through the plane A F, from F to C (at which point the foot would be in equinus), and then around the malleolar axis A F, through the plane B D, from C to B (when the foot would be brought to its normal position); instead, I say, of moving round these two axes, and through two distinct planes, first, from F to C, and then

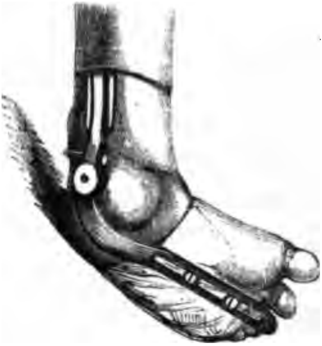
FIG. 189.



from C to B, the point adopted, F, could move round one axis G, placed at an angle of 45° to the two former, passing through one plane only from F to B.

It is therefore quite possible for an apparatus to be constructed which would, from one centre, restore an equino-varus to a normal condition. The annexed diagram (Fig. 190) depicts an instrument fabricated with this object.

Fig. 190.



The mechanism consists of a metal stem, furnished at the point which I have just laid down as being the common centre of movement with a rack-and-pinion joint, coincident in its plane with a line drawn from the great-toe joint of the deformity to the point which this articulation would occupy in the normal limb. The lower extremity of the leg-stem bears a padded metal plate, which embraces the metatarsus, and gives the mechanism control over the entire foot. Its upper limb carries calf- and thigh-bands, which secure the instrument firmly to the leg, while at the same time they afford a point of resistance for the action of the lower portion of it.

Upon moving the rack-and-pinion centre, the foot becomes gradually unfolded, and the necessity of dividing the mechanical treatment into two parts is thus done away with.

I have named this instrument the Orthopede.

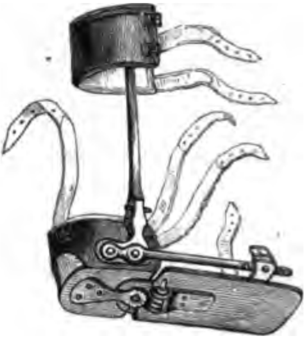
The instrument described at page 478, for the relief of valgus, may also be used for varus. The mode of its application, when adopted for varus or valgus, consists in the adaptation of the perpendicular leg-stem to the *outer side* of the limb for the former, the *inner* for the latter deformity.

For patients residing at a long distance from the mechanicians, and who cannot readily have alterations made in the construction of their apparatuses, this instrument is invaluable, for it is little apt to be placed out of order, and it is easily applied.

On referring to the instrument, it will be perceived that a small pad, which supports the tuberosity of the scaphoid in valgus, rests in varus upon the cuboid, and thus tends to expand the inner margin of the foot by pressing on the convexity, and expanding the extremities of the curve. Owing to the peculiarity of the action of the rack-and-pinion at the back of the heel, there is little cause for fearing any abrasion of the skin over the cuboid during the mechanical treatment.

Another description of appliance (Fig. 191) is constructed, by dividing the shoe-piece into two parts, and placing a ratchet-screw at the point of their junction (which is situated just below the point of convergence of the astragalus, calcaneus, cuboid, and scaphoid bones). By this arrangement an endeavour is made to obtain absolute control over the lateral motion of the anterior two-thirds of the foot, without subjecting the cuboid region to a painful degree of pressure, an untoward event which is occasionally a source of annoyance in cases of long standing, where the toe-strap and horizontal bar are employed in overcoming adduction, *without* the assistance of this division of the sole-piece. In order that the sole-plate may readily follow the direction assumed by the foot in its deformity, it will often be found advisable, when constructing this instrument, to add a rack-and-pinion joint to the toe-bar, just over the cuboid: by this means, the horizontal lever and sole-plate mutually contribute to perfecting each other's mechanical action. This apparatus is also furnished with a double rack-and-pinion leg-stem. On application, the division in the sole-plate, and the ratchet of the toe-bar, allow an accurate adjustment to the shape of the foot. In order to bring the instrument into action, it is necessary that the toe-bar rack be first moved in an outward direction, by which proceeding a tension *against* the plantar arch is obtained: the ratchet in the sole-plate is next so turned that the foot may be abducted, when, since the os calcis and astragalus are firmly held by the heel-socket of the shoe-piece, the scaphoid becomes gradually drawn outwards. This process entails a separation of the mechanical treatment into two distinct stages. In the *first*, which has just been described, we endeavour to reduce the foot into a state correspondent with that of simple equinus, and where this has been accomplished; the *second* stage of treatment is commenced, by depressing the heel, which is brought about by the action of the two ratchet-screws at the malleoli, and, in this manner, by finally overcoming the obliquity of the sole of the foot, the patient's limb is restored to its proper condition.

FIG. 191.

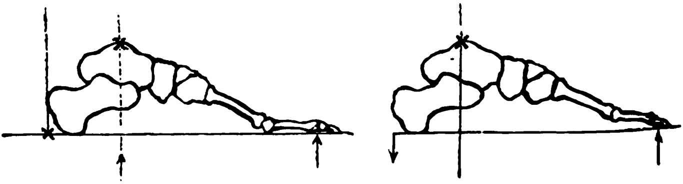


An instrument which is occasionally used at the Orthopædic Hospital, and called "Mr. Tamplin's shoe," is constructed as follows:—A metal splint, which receives the back of the leg, is prolonged as far as the extremities of the toes. Just under the heel, where the apparatus is rendered angular, for the accommodation of the foot, which is in a state of extension as regards the leg, a ratchet-screw is attached, corresponding, in the plane of its action, with the mesial line of the leg. A strip of metal, about the breadth of the fibular surface, and carrying at its inferior extremity a horizontal bar furnished with a toe-strap, is joined by a hinge to the external lateral margin of the leg-splint. Occasionally, the lateral surface of the splint is carried *above* the knee, being, in this case, furnished with a free joint coincident with that of the articulation. The entire apparatus is fixed to the leg by long straps of webbing, which pass through slits made in the metal splint.

When this contrivance is brought into action, the foot is abducted by the horizontal toe-bar, and an attempt made to change the angle formed by the foot with the leg, by so turning the ratchet-screw, that the front of the leg and dorsum of the foot may be more nearly approximated. I believe that this instrument is based upon erroneous principles, and for this reason:—The axis of motion around which the foot moves during the formation of equinus, is placed in the tibio-tarsal joint; consequently, the radius of deviation from the rectangular position comprehends, *anteriorly,* small portions of the os calcis and astragalus, together with the rest of the tarsus, and the entire metatarsus; whilst *posteriorly* it simply involves the remaining portions of the astragalus and calcaneus.

The anterior radius moves in a downward, the posterior in an upward direction, thus forming segments of circles at their extremities, proportionate in area to the distance which intervenes between the centre of motion and the extremity of either radius. It may therefore be laid down as an axiom, that no artificial centre which does not coincide with that demonstrated as the *natural one,* can possibly correspond with the mechanical position assumed by the foot in equino-varus. In the apparatus attributed to Mr. Tamplin, however, the axis of the instrument is placed immediately below the posterior margin of the os calcis; hence, *the whole of the foot* is embraced by the radius running from that point to the end of the toes, the said radius being represented by the action of the sole-plate. Now when the rack is turned, for the purpose of diminishing the inordinate extension of the foot upon the leg, the heel is uplifted, instead of being depressed. To show this more clearly I have appended two diagrams, which will, I think, render the error committed in the mechanical construction of the shoe tolerably clear.

FIG. 192.



The asterisks placed above the astragalus are intended to represent the natural or true centre of motion; that at the heel, the one laid down by Mr. Tamplin. The arrows indicate the direction taken by the heel and toes.

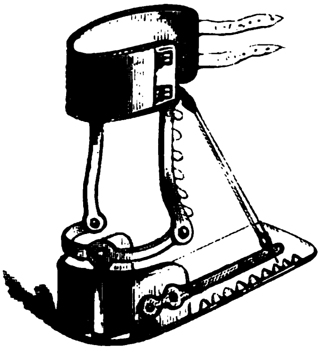
It cannot be urged that the instep straps afford the necessary centre, as, from their attachment to the sole-plate, they are compelled to move with it in an upward direction. I do not imagine that this apparatus is often made use of.

In the appliances previously noticed, the extending power has depended, in all, either upon the action of tangential screws, or of a powerful metal spring, or both. There are still other means available for the reduction of varus. I have, for a long time, employed India-rubber cords for this purpose, and consider that, if they are applied with care, their mode of action is often even superior to that afforded by any other mechanical agent with which I am acquainted.

An excellent apparatus for varus, which acts by elastic force, is thus constructed:—An ordinary metal shoe-piece receives the foot, a small stem of metal, corresponding by a free joint with the longitudinal axis of the foot, being fixed to its posterior margin; this stem is joined at right angles by a curved metal bar, which extends from the inner to the outer ankle-joint. At each extremity of this bar a free joint affords attachment to two leg-stems, joined at their upper ends by a calf-band. Metal eyes are placed on the upper margin of these stems, for the reception of India-rubber cords.

On applying this instrument, the foot is first secured in its proper receptacle, by two straps which pass over the instep, while a third is fixed like a skate-strap, just over the astragalus. The toe-strap, belonging to the horizontal stem, is then drawn as tightly as possible, short of hurting the patient. An India-rubber cord is now extended from the outer leg-stem to the toe-bar, the resultant action being singular; for, owing to the disposition of the posterior (calcial) and lateral (malleolar) centres, the external margin of the foot is uplifted, and the heel depressed, by one and the same elastic cord. The most prominent advantages accruing from this piece of mechanism are,—the removal of the deformity by a power analogous to that which created it; and the maintenance of complete mobility of the foot throughout the whole period of treatment. The India-rubber cords can be increased in power to any extent which could be desired, by employing them of various sizes; and the elastic character of the resistance much diminishes the probability of abrasion being produced. Another good point about this instrument is, that the same apparatus is equally applicable to either varus, valgus, equinus, equino-varus, and calcaneus; as it is only necessary to vary the position of the cord, to obtain those particular mechanical actions, which may be desired for the amelioration of any one of these maladies. The only ground on which it is ever likely to be objected to is, that the elastic cord might elongate the tendons too rapidly; but this inconvenience can readily be

FIG. 193.

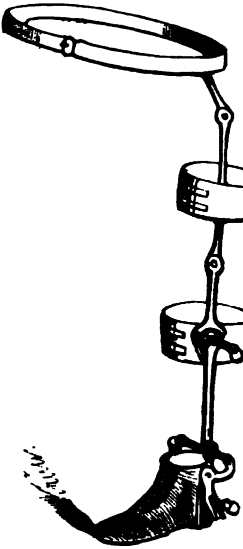


obviated, by employing cords of a proper degree of strength—the age and condition of the patient being taken into consideration.

I shall now describe another kind of apparatus (Fig. 194), which will be found very efficient in many cases. The foot is received in a properly moulded metal shoe, on the external margin of which a stem, also of metal, is fixed, rising as high as the outer ankle, where it forms a lateral hinge with a steel leg-stem. The latter ascends the leg as far as the middle of the thigh, and is made with a free joint at its point of coincidence with the knee.

This stem has also an ankle-joint, governed by a screw, which corresponds in action with that of

FIG. 194.



the equinus. Just below the ankle-joint, and connected with the lateral hinge already mentioned, there is a small bifurcated downward prolongation from the leg-stem, the aperture, or slit, of which receives a pinion, forming by the shaft a worm, on which a nut of metal is screwed. Thus far the instrument is constructed with a view of overcoming the obliquity of the metatarsus. A horizontal screw is placed at the upper part of the leg-stem, just below the knee-joint, which, by acting against a small lip of steel, rotates the entire lower portion of the stem, and, of course, with it the shoe-piece. This movement is intended to counteract the adduction.

In employing this instrument, the foot must first of all be firmly fixed in the shoe part by straps; the next step being to secure the calf and thigh-bands. Then screw the nut upon the ankle pinion, in order that the sole of the foot may be everted: the horizontal screw at the calf portion of the leg-stem may now be turned, which has the effect of rotating the foot outwards, and bringing it into a condition of equinus. Lastly, flex the ankle ratchet, in order that the anterior part of the foot may be uplifted, and the whole restored to a normal state.*

This apparatus is as simple in its mode of application, and as efficacious in its operation, as any with which I am acquainted; while, by its rotative power being applied in a line correspondent to the longitudinal axis of the leg, the cuboidal surface is exposed to a very slight amount of pressure—a matter of no slight importance in the management of mechanical appliances for Talipes Varus.

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* This instrument was constructed at the suggestion of Mr. Le Gros Clarke, and bears his name.

The next instrument (intended for adult varus) was suggested by me to Mr. Adams, who has already published an account of it.*

In construction it is based upon the principle of dividing the treatment of equino-varus into two distinct stages:—1. For the varus; 2. For the equinus; and likewise upon an assumption that there is a transverse joint in the tarsus, which separates the calcaneus and astragalus from the remaining bones of the foot. The instrument (Fig. 195) is thus made:—To the leg a metal trough is adapted, jointed at the knee, and terminating in a lever, furnished with four rack-and-pinion centres, which lever extends as far as the end of the toes, where a metal plate slides upon it for the reception of the foot at the metatarso-phalangeal articulation; a triangular piece of metal forming a rest for the heel. All these axes are so arranged, as to correspond with the various planes assumed by the foot in its abnormal condition, at points coincident with the centres of osseous displacement. Thus, the first joint, by being placed opposite to the cuboid, acquires a power of unfolding the foot in a downward direction, and is enabled, by exercising a leverage, to withdraw the navicular bone from its approximation to the inner malleolus; the second centre, which acts rectangularly to the first, uplifts the front of the foot; the third, perpendicular to the second in its action, depresses the inner margin of the metatarsus, and unfolds its transverse arch. By the combination of these three actions the foot is brought into a state of equinus; when the fourth centre, which is placed at

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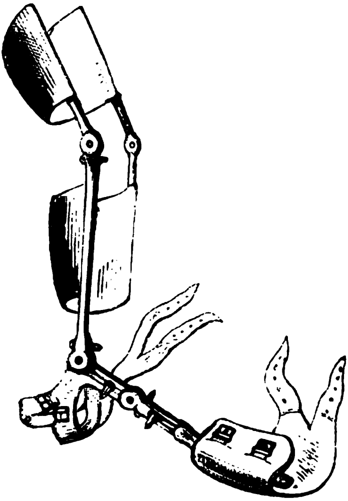
* 'Medical Times,' Adams' Lectures.

FIG. 195.



a point exactly opposite to the malleolar axis, uplifts the foot, and depresses the heel, by a movement similar to that of the ordinary apparatus for equinus. In this instrument there is an absence of pressure against the cuboidal region; the deformity of the foot being overcome by a counter resistance obtained from the fibular surface of the leg; for which reason the leg-trough should be thickly padded at this part. The power of the instrument is very considerable, yet it can be regulated with the greatest delicacy, and there is no form of varus, however severe or complicated, which it cannot overcome, if used skilfully, and with a thorough knowledge of its practical details.

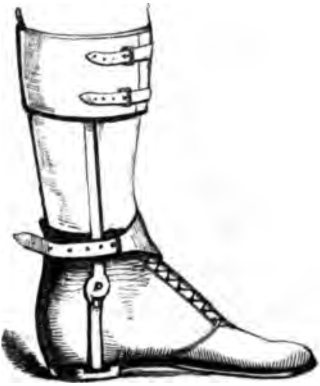
Maintenance of the position of the foot after the relief of valgus or varus.—In addition to the instruments employed for the reduction of varus or valgus there are others intended only to restrain the limb in its corrected position, as also for adaptation in cases where there is simply a tendency to club-foot.

Of those which I shall here speak of, some are intended for the purpose of exercising the limb, when the mechanical distortion has been remedied; others for cases where extension is combined with exercise. For the sake of convenience, these appliances may be divided into two groups. In the first are placed the instruments which simply retain the foot in position; in the second, those which likewise extend and exercise the limb.

The simplest form of appliance for retention of the foot in infantile cases is a padded splint, which is shaped to the tibial surface of the leg, and rendered rectangular at the shoe-part. When applied, it is bound on the leg by a few folds of an elastic roller. This splint can be worn by night as well as by day, as it is perforated, in order that the limb may be kept cool by the free admission of air.

The next retentive instrument (Fig. 196) for

FIG. 196.

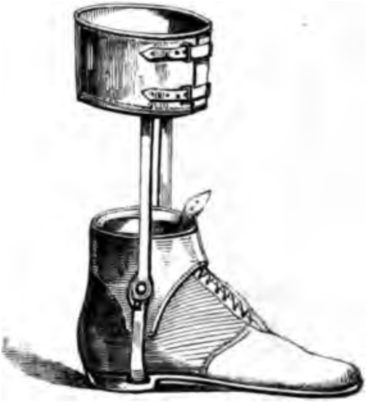


varus is composed of a metallic stem, passing as high as the centre of the calf, on the tibial or *inner* surface of the leg. This stem is attached below to a stiffened laced-boot, and is furnished at the ankle with a stop-joint, *i. e.*, one that is limited in action to flexion of the foot upon the leg, by a metallic point, or spur. This is intended to prevent re-contraction of the tendo-Achillis, which might take place if a too ready extension were permitted.

The outer ankle is supported by a triangular strap, which preserves the foot in its corrected posture, by acting against the metallic stem.

Another appliance (Fig. 197) consists of two

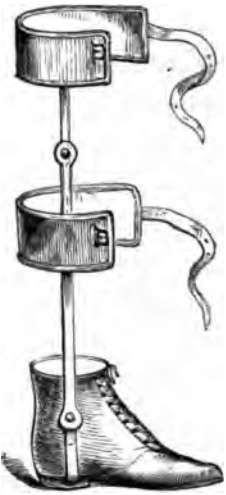
FIG. 197.



lateral stems, fixed to a calf-band, and furnished with stop-ankle-joints; the object of which is to maintain the plantar surface of the foot in a horizontal position, especially where it manifests any tendency to obliquity. Since the two stems are fixed to a calf-band, they compel the bottom of the foot to remain at right angles with themselves, for it would be impossible for the sole to become oblique, without a shortening of one of the perpendicular bars.

The next kind of apparatus (Fig. 198) is made by carrying a leg-stem as high as the middle of the thigh; joints being placed at the knee and ankle. It is customary to apply this instrument either on the outer, or on the inner side of the leg. If the former plan be adopted, the boot is so arranged as to turn the toes out at a considerable angle; whilst the padding, lining the calf and thigh-bands, is composed of a material which will cling to the limb—thus preventing longitudinal rotation of the instrument around the leg. If the latter plan, the boot is, in like manner, rendered horizontally oblique, *outwardly;* and is also furnished with a very strong stiffener on the inner side, having a triangular strap which acts against it. By either method of application the desired end will be attained, if the instrument is carefully arranged. It therefore rests with the surgeon to adopt whichever plan he considers as likely to be most agreeable to the patient. It must, however, be confessed, that if the tendency to inversion of the foot be *very considerable,* neither of these appliances will be found available.

FIG. 198.

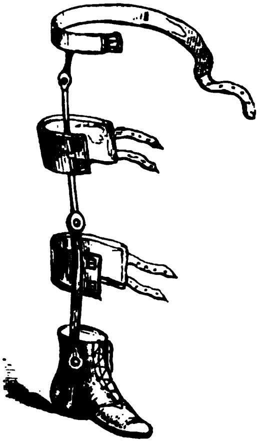


The best direction, mechanically speaking, that can be given for selecting the side on which the instrument should be applied, is, that if the outer ankle has a tendency to eversion, the apparatus should invariably be applied to the inner side; if, however, there be no lateral deflexion, but simply a disposition for the foot to be adducted, it may be applied to either side indifferently.

Another appliance (Fig. 199), constructed to prevent lateral inversion, consists of a perpendicular stem, worn on the outer side of the leg, and attached below to the boot; while above it terminates in a padded band, which surrounds the pelvis. Joints are placed at the ankle, knee, and hip, in order that the instrument may be freely flexed. Since the pelvic band is elliptical, it is hardly possible for it to turn upon the body, however strongly it may be urged to do so by the tendency of the leg to inward rotation. The perpendicular stem is thus maintained in the same plane as the mesial line of the body, the foot being held in a correct position, by the oblique *set* which is given the plate by which it is secured to the instrument.

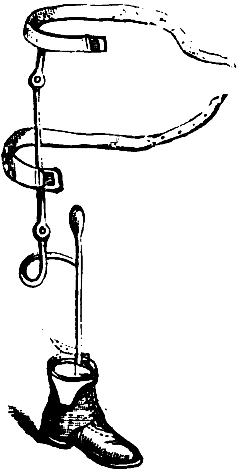
This instrument is sometimes modified by the addition of an inside stem. The object of which is, to keep the sole in a strictly horizontal plane, and likewise to admit of a triangular strap being fastened around the outer ankle.

FIG. 199.



Another apparatus (Fig. 200) has a perpendicular stem, reaching as high as the top of the calf on the inside of the leg; it is there joined by a transverse slip of steel, passing across at the back of the leg, and attaching another perpendicular stem on the outer side, which is jointed at the knee and hip, and screwed to a pelvic band. The only benefit gained by this arrangement is, that it requires less metal, and is consequently lighter than the one previously described; it also exercises a greater amount of rotative power upon the foot, owing to the mechanical forces being transmitted in a horizontal direction through the calf bar; thereby securing the external obliquity of the foot.

FIG. 200.



A very excellent instrument is used for overcoming inversion of the foot in the French school of orthopædy. It consists of a metal stem, jointed at the knee and ankle, and fixed to a laced boot at the inferior extremity, the superior being attached to a padded metal pelvic band. The leg-stem is secured to the pelvic band by a perpendicular hinge, one side of which contains a small horizontal screw.* On turning this screw, the whole of the leg is rotated outwardly, thus compelling abduction of the toes, and at the same time effectually overcoming all tendency to inversion.

The same principle was carried out in England long ago; but instead of a screw at the waistband a steel slide was made use of, governed by a buckle and strap at the back of the pelvis. By lessening the distance posteriorly between the metallic joints which correspond with the hip-joints, the leg-stems are made to rotate slightly in an outward direction, and thence, by an action already explained, abduction of the foot is induced. To produce this effect, the patient is compelled to wear a perpendicular stem, &c., on each leg; whereas, by the French plan, one instrument answers the purpose quite as well as if two were used.

In concluding this description of the instruments used for retention, after the deformity has been ameliorated, it may be mentioned that all the various appliances used in the mechanical treatment of varus or valgus are capable of keeping the foot in position after the deformity has been reduced, if maintained on the limb for a sufficiently long period.

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* Bonnet, 'Traité de Thérapeutique des Maladies Articulaires,' page 506. The engravings, Figs. 201, 202, 203, are taken from Bonnet's work. They show the best form of appliances of the kind.

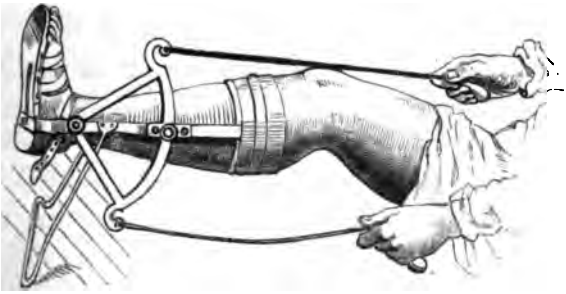
Attention must now be given to a class of instruments much employed in this country.

They are based upon a theory that the mobility of a contracted limb may be restored by mechanical exercise. While the instruments in common use act by slow and tedious stages, the appliances which are now about to be described perform their duty by vigorous, rapid, and often *sudden* movements. They aim at destroying, by movement, the mechanical opposition to cure, which is caused by muscular contraction and undue tension of the tarsal ligaments; and they also tend to diminish any loss of mechanical power which may have befallen the muscles during the period in which their action was suspended. Manipulations, too (or movements with the hands), have long been considered valuable agents in obtaining free movement and muscular exercise; but as the direction and intensity of the force depends upon the skill and experience of the professional rubber, the results are not likely to be so satisfactory as when mechanical powers are substituted, the forces of which can be exactly estimated.

Thus, it is practicable to construct instruments, intended for the purpose of exercising the foot, with a graduated scale, so arranged that the patient may be enabled not only to estimate the amount of motion bestowed, but even to co-operate actively with the surgeon.

The first instrument to be described is intended for use in cases where, from the varus having been originally slight, the contractile tendency of the tendo-Achillis only has to be guarded against. Here the endeavour is to obtain flexion and extension at the ankle-joint. This is accomplished in the following manner:—An ordinary shoe-piece receives the foot, which it retains by means of two straps, passing over the instep. A metal stem with a free ankle-joint is attached to the outer margin of the shoe-piece, but instead of merely constructing this joint of two pieces of steel (about the size of a shilling), held together by a rivet in the centre in the ordinary manner, the lower part of the stem is expanded upwards in a fan-like form, and terminated at the periphery by two curved points, which receive the end of a cord. The upper part of the stem is secured to the leg by a padded calf-band; and in order to prevent uplifting of the whole leg, when power is applied to the ankle for the purposes of flexing and extending the foot, the calf-stem is usually fixed to a heavy piece of wood by a triangle of wire. The cord proceeding from each end of the fan-shaped ankle-joint is held in the hands of the patient, who can readily produce a rapid motion by pulling each cord alternately. If the periphery is marked by numbers, the amount of motion gained daily can be easily ascertained, as also the degree of flexion and extension.

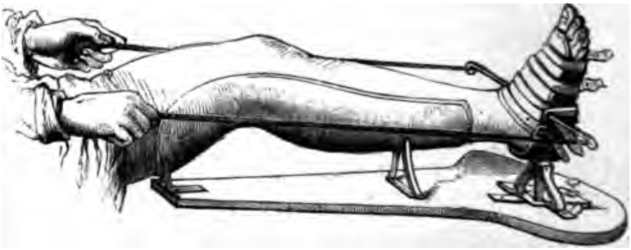
Fig. 201.



There is another very simple plan for accomplishing the same object, in which a strap sufficiently long to reach the hand is fixed to the toe of a leather boot, whilst another is attached to the heel. The alternate action of these straps, combined with the resistance of the patient's body, enables the foot to be flexed and extended in a moderate ratio. The first described apparatus, however, is by far the more efficacious of the two.

Where it is necessary to reduce the obliquity of the sole, as well as extend and flex, a different instrument (Fig. 202) is recommended. This is constructed as follows:—A pivot-joint secured to a wooden frame, which extends as high as the middle of the thigh, and affords attachment to a trough for the reception of the leg, is fixed to the posterior and external surface of the heel-piece of a padded shoe, in which the foot is secured by three straps passing over the fore part, a thick pad of leather being

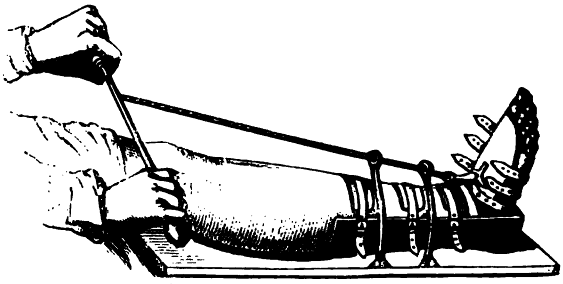
Fig. 202.



placed beneath them. On either side of the heel a cord is attached to the margin of the shoe. When the patient pulls these, a rocking motion is produced, which extends the external and internal margins of the sole, alternately.

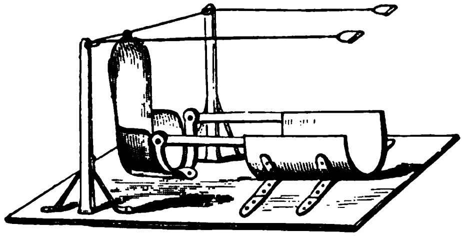
A fourth instrument (Fig. 203) is made use of for the removal of any tendency the foot may show for adduction. This object is secured by placing the foot in a shoe-piece constructed with a dorsal pad, and connected with the leg by an ankle-trough, which is fixed to a wooden frame a little longer and broader than the leg itself. Two arches of steel spring from the outer edge of the frame, which are perforated by circular apertures at their upper ends. Through these openings a metal rod passes, furnished with a cross-handle above, where it is within reach of the patient's hands, and terminated below by a triangular flange of metal, which forms a part of the dorsal pad. When this apparatus is applied the cross-handle is moved upwards and downwards by the patient, the effect being to alternately adduct and abduct the sole of the foot. It is needless to observe that, since the tendency of the foot is mainly one of adduction, the greatest amount of speed is gained at that period of the motion in which the external side of the cross-handle is depressed. This exercise is particularly well calculated to expand the inner lateral arch of the foot; because, the heel being firmly held in the shoe-piece, and the axis of motion made to fall about the centre of the tarsus, a considerable strain is brought to bear upon the inner edge of the arch formed by the plantar fascia.

FIG. 203.



The three instruments described (Figs. 201, 202, and 203) furnish the means requisite for the treatment of club-foot by movements, but for each description of movement a distinct apparatus is necessary. This inconvenience may be obviated by making use of the following apparatus, which is arranged in such a manner that it admits of every variety of motion (Fig. 204).

FIG. 204.

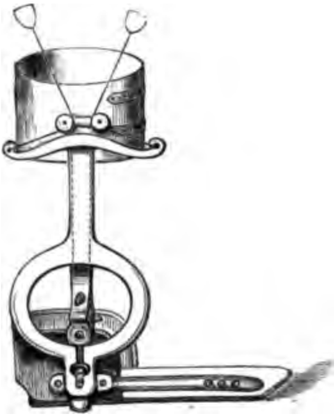


The foot is received by a metal shoe-piece, to which a stem is fixed at the posterior margin of the heel. This stem rises as high as the ankle-joint, and supports a small steel bow, which extends to the outer and inner malleoli, where it is attached by joints to the leg-stems. The stems terminate in a calf-band, which is fixed to a wooden frame by steel triangles. Two perpendicular rods furnished with pulleys are attached to that portion of the wooden frame which is opposite to the shoe-piece. Through these pulleys a cord passes, one end of which is secured to the toe-part of the apparatus, while the patient holds the other in his hand. When the cord is tightened, motion is first communicated to the shoe in a lateral and horizontal direction; but since the whole shoe rotates on the heel-centre, the lateral margin of the foot is uplifted at the same time, *i. e.*, it is drawn laterally outwards. As there is also a joint at the malleolar axis, the toe-part of the instrument is uplifted; thus all three motions, abduction, flexion, and extension, are *simultaneously* produced; a circumstance which gives the apparatus an advantage over all the Continental appliances of a like description. This instrument is an invention of my own.

In another appliance (Fig. 205) the means employed for the cure of the deformity, and those taken to obtain exercise and retention in a normal position, are combined together. There is but one instrument of this kind, so far as I know, and that one I invented for a patient who was under the care of Mr. W. Adams.

The single rack-and-pinion apparatus described at page 490, Fig. 178, was so modified that, instead of the pinion being permanently fixed against the rack, as is customary in all contrivances of the kind, it was furnished with a "slot," which allowed the pinion to be thrown downwards, and, consequently, out of contact with the rack, whenever a small screw was loosened which held it to that part of the instrument. The lower ankle-stem had two steel pins rising from its surface, on which a lever, with cords at each extremity, could be instantly fitted, by simply turning a small nut. Thus, in a few seconds an ordinary varus apparatus can be rendered capable of receiving a rapid motion, by which flexion and extension will be produced.

FIG. 205.



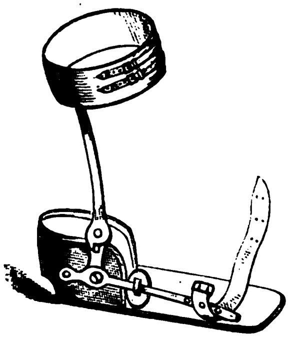
There is a variety of varus which must not be passed unnoticed; more especially since I had frequent and unwonted opportunities of studying its characteristics during the progress of the

Crimean war. I allude to that form of varus which is sometimes produced by gunshot wounds.

The first case of the kind for which I had to construct an apparatus, was an officer (a patient sent to me by Mr. Fergusson), whose ankle was perforated by a rifle-ball in the Crimean campaign. The ball had been extracted, but owing to inflammation, which set in during the progress of reparation, the muscles became contracted to a considerable extent. At Mr. Fergusson's suggestion, I applied an apparatus (Fig. 206) which is here described, and with the happiest results. A padded shoe received the heel, on the external margin of which and in a perpendicular line with the leg was a spring lever, furnished with a stop at the ankle. Parallel with the metatarsus there was a spring, furnished with a webbing-strap, and fitted with a cuboidal pad, which spring embraced the toes, the patient walking on crutches during the whole period of treatment.

The constant traction of the springs gradually overcame the inversion, and a boot, fitted with two lateral stems, and stop-ankle-joints, such as is described at page 536, Fig. 197, retained the foot in position, until all chance of contraction had passed away.

FIG. 206.

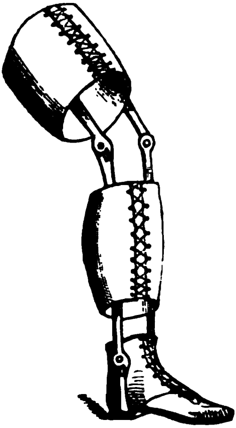


The second instrument I made for another officer, likewise sent me by Mr. Fergusson. Any pressure upon the front part of this gentleman's foot was productive of considerable pain, so that the surface upon which power is ordinarily exercised (the dorsum of the foot) was unable to afford leverage to an instrument. For this case I constructed an apparatus in which two lateral stems proceeded from a thigh-plate, articular centres being arranged in them at the knee and ankle in such a way that the former joint was prevented from passing backwards out of the straight line, while another stop in the latter kept the shoe-plate from rising beyond a rectangle with the leg. The foot was received in a stiffened boot, laced to the toes, the sole of which held the shoe-plate of the instrument. The inversion in this case was fortunately trifling, and mainly attributable to the ease experienced by the patient on placing his foot in a position of equino-varus.

This piece of mechanism produced very gratifying results when applied, for the patient could *then place* the whole of his weight upon the instrument without painful pressure being made against the astragalus at the anterior part of the foot, which must have occurred had the joint at the ankle-piece been undefended by a mechanical stop. The power and habit of taking walking exercise effectually overcame all tendency to varus, as the pressure upon the toe-plate extended to the heel, until the foot and leg came to be at right angles, while the rest of the shoe-piece kept the foot constantly abducted.

The gentleman for whose use the apparatus was constructed could hardly bear the slightest weight to be rested on the foot at first, but, in the course of a few months, he was able to dispense with all mechanical support, and now walks with as free a gait, and well-shaped a foot, as if nothing had happened.

FIG. 207.



During the war a large number of cases of this class passed through my hands, but as the features presented, by almost all of them, were of a similar character to those already described, viz., *positional* equino-varus, due to the condition under which the foot had been placed during the healing process, and rarely accompanied by such an amount of contraction of the tendons as to need surgical division, it is unnecessary to say more concerning them.

Amongst the most remarkable cases of gunshot talipes on record is that of General Garibaldi.*

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* For detailed account of the wound, see 'Lancet,' 1862, vol. ii, p. 548.

A semi-spent and fractured Minie ball struck the outer malleolus, glanced across the front of the astragalus, and buried itself in the body of the internal malleolus. Considerable inflammation followed this injury, and the joint lost a large proportion of its natural mobility.

By request of General Garibaldi, and in the presence of his medical friend and adviser, Dr. Basile, I made a careful examination of the joint, with a view of determining whether any mechanical contrivance could be devised for diminishing the pain whilst standing, increasing the mobility of the joint in walking, and giving greater stability to the General's gait. He had hitherto been compelled to save his foot by means of a hand-stick.

The foot presented the appearance of slight equino-varus, being retracted at the heel a little, rotated on its longitudinal tarsal axis in an upward direction, and rather adducted towards the mesial plane. On moving the foot by the hand I was surprised to find a considerable amount of motion without producing any corresponding tension of the tendo-Achillis. The foot could also be easily abducted. Pain arose directly upon its being pressed with a freer degree of force in an upward direction.

From previous experience in Crimean gunshot cases, where, owing to the Russian soldiers firing low, the feet of our men were frequently struck, I was led to suppose that the motion found in the General's foot had its origin from some other articulation than that of the tibio-astragaloid. In fact, I suspected that semi-anchylosis existed in the natural joint, and that a certain amount of motion existed between the astragalus and scaphoid bones to account for the peculiar movement. On holding the heel firmly in one hand and moving the foot with the other, this view was at once confirmed, and led to the deduction that there were semi-anchylosis of the ankle-joint and movement below the astragalus and scaphoid, the pain being engendered by pressure between the mal-placed facets of these bones. In a word, that there was no true axial movement, but only a shifting of the scaphoid upon the astragalus.

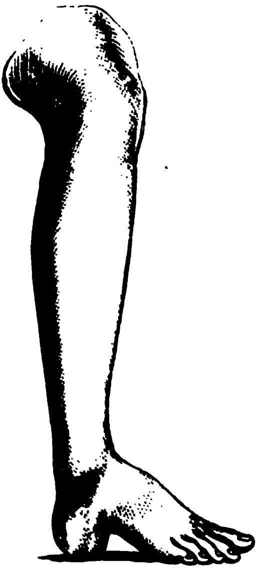
Having determined this, it became necessary to devise such an instrument as should permit but slight motion between the two bones just mentioned, and be so constructed as never to permit their facets to come into violent contact.

At the same time the adduction had to be overcome, as otherwise the foot rested principally upon its outer edge. The form of apparatus adopted was a lateral rod fixed to a laced boot on the *inner* side of the leg, having a joint so constructed as to permit the front of the foot to move but slightly, the whole weight of the body being received by a mechanical "stop" placed within the artificial joint. In order to prevent the toes from touching the ground and thus tripping the General whilst walking, a strong india-rubber cord, acting as the tibialis anticus, secured the foot against accident. This instrument was adjusted, and enabled the General to walk across his drawing-room without any pain and with a greatly improved gait.

Owing to the General unexpectedly leaving England, I had not the opportunity of doing more than apply the instrument a day or two before starting, when the result was most satisfactory. Since this time, however, the rough ground of Caprera has demolished the resistive principle of the instrument, and the General still remains, as, unfortunately, he ever must be, lame. Should he again visit England I feel confident of being enabled to construct for him such an apparatus as will enable him to walk without either pain or hand-stick.

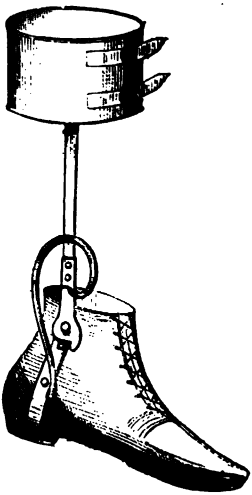
D. *Talipes calcaneus.*—A falling of the heel, and uplifting of the rest of the foot without much lateral distortion, are the distinguishing features of this deformity (Fig. 208). The plantar arch, too, is occasionally contracted, by which occurrence the outer extremities of the metatarsal bones and the os calcis will be approximated. In children,

Fig. 208.



the foot is simply flexed to a greater angle than is ever assumed during exercise in a normal state; but in adults, in addition to the downfall of the calcaneus, and consequent lengthening of the tendo-Achillis, the sole of the foot is almost invariably contracted in its long axis. In slight cases, the following instrument (Fig. 209) is well calculated to bring about a mechanical restoration of the foot to its normal position and actions.

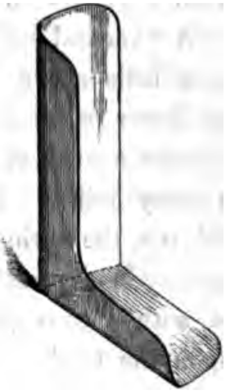
FIG. 209.



A metal stem, furnished with an ankle-joint, and bound to the leg by a calf-band, is fixed to the outer border of a padded shoe, in which the foot is received. A "vertical spring" is attached to this leg-stem, a little above the axis of the ankle-joint; the lower extremity of the said spring resting against a small steel pin, which is guarded by an ivory roller. By its pressure against this steel pin, the spring acts in such a manner as to induce a depression of the front part of the foot, with a consequent diminution of the strain upon the tendo-Achillis. It likewise extends the muscles of the front of the leg, enabling the patient to walk with greater ease and security, by replacing the leg upon its proper base of support.

When tenotomy has been previously performed, another apparatus may be adopted, which consists of a carefully moulded and well padded back-splint (Fig. 210) made of metal, with a sole-piece at the lower end, set at an angle of a rather greater degree than a right angle, the object of this being that the front of the foot may be brought downwards, the heel, meanwhile, being supported by a very soft pad, which should be placed beneath it at the point of junction of the foot- and leg-plates. This

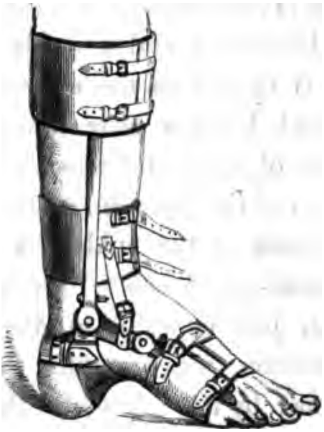
FIG. 210.



splint may be kept in place either by adhesive *strapping*, or bands of webbing; the former, however, being preferable, because the foot acquires a tendency to draw the splint perpendicularly downwards from a leverage which is exercised by the front of the foot in an upward direction, thereby transferring force to the calcaneus, which, by acting as a fulcrum, aids in bringing about a displacement of the leg-splint, unless the splint be so firmly bound on that it cannot be moved. This requisite can only be secured by a judicious application of adhesive strapping.

An apparatus (Fig. 211) which I have recently

FIG. 211.



invented is likely to be of much service in cases of great severity. It is made as follows, and it is intended to extend the plantar arch, raise the toes, and throw the prominent calcaneus backwards and upwards, by using it as a fulcrum.

To the lower extremity of a perpendicular stem, which passes down the leg on its outer side, and in coincidence with the malleolar axis, a rack-and-pinion centre is attached, from which there proceeds a small arm of metal, supporting a plate which is accurately moulded to the anterior surface of the calcaneus. Since this stem is the radius of a circle, formed by the malleolar axis as a centre, with the extremity of the calcaneus as a point in the circumference, the arm necessarily moves backwards and upwards. Another stem, which is carried to the extremity of the metatarsus, and bears a plate into which the plantar surface of the metatarsus and the proximate phalanges of the toes are received, is placed towards the front of the ankle-rack. Finally, another rack-and-pinion centre is established in the foot-stem, just opposite to the calcaneo-cuboid articulation, which uplifts the anterior part of the foot by its action; for the stem becomes a radius to a circle which involves the anterior two thirds of the foot.

By these two movements the plantar arch is gradually expanded, and the foot restored to its natural condition. I feel assured that this apparatus would conquer calcaneus of any degree of severity, no matter how great; taking it for granted that in this, as in *all* other forms of club-foot, tenotomy had been performed by the surgeon prior to the application of an apparatus.

With the description of this instrument the portion of the work devoted to club-foot ends. As regards the secondary distortions arising from a combination of two or more kinds of *primary* *deformity, e.g.* equino-valgus, equino-varus, calcaneo-valgus, calcaneo-varus, all the appliances which are constructed for the treatment of the primary deformities may be employed with success in those cases where the displacement has been so considerable and continued for such a length of time that some one or other of these secondary abnormities has been superinduced.

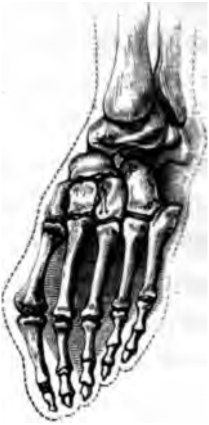
5. *Deformities of the Toes.*—Deformities incidental to, and affecting, the shape or proper action of the toes, are of such frequent occurrence, that they merit a far greater share of attention than has hitherto been bestowed upon them. Every one knows how much annoyance and pain is experienced by those who have had the misfortune to be afflicted by that very common and unsightly malady, a bunion; yet few have cared to ascertain the primary causes which lead to this painful malformation of the toe-joint, and the means by which it may be most readily cured. The toes, which form the anterior third of the human foot, are so articulated or joined together as to permit a limited amount of motion in almost every direction; *e.g.*, they can be uplifted, depressed, or moved laterally. This mobility of the joints is due to the peculiar man-

ner in which they are articulated: the opposing surfaces of each bone being crusted with a smooth cartilage, so arranged as to facilitate the gliding movement of bone upon bone in every direction; the joint being closed in and completed by strong ligaments above, below, and laterally, these ligaments not only holding the bones together, but checking and restraining the amount of motion within proper limits. Every joint, too, is separate, being a perfect shut sac, lined with a peculiar membrane, the synovial membrane, which secretes a kind of fluid *joint-grease*, the synovia. The advantage in this plan of connecting media is that it allows of a considerable range for motion, while imparting at the same time such an amount of horizontal strength as to render dislocation or disjunction of the bones almost impossible, save by the employment of extraordinary violence. That, however, which is so difficult of accomplishment by sudden and violent actual force, is partially brought about during the formation of a bunion, by the slow yet sure influence of a power acting for a considerable period in a direction opposed to the horizontal resistance of the ligaments which connect the internal anterior margin of the first metatarsal bone with the internal posterior margin of the first phalanx of the great-toe—or what is commonly called the joint of the great-toe. A bunion may therefore be described as a widening of the metatarso-phalangeal joint of the great-toe at its internal lateral margin. When this occurs, the longitudinal axis of the great-toe, in the normal state coincident with that of the first metatarsal, is not only diverted from its original direction, taking an unnatural one outwards, but a gap is created within the joint between the internal osseous surfaces of the two bones, leading to an abnormal development of the integuments which cover the joint laterally, and the ultimate establishment of an unsightly callosity, painfully sensitive to pressure.

The proximate mechanical cause of bunion may most frequently be traced to an absurd habit of having boots made so narrow across the toe-joints as to necessitate the cramping of this part of the foot within a space far too confined for the preservation of a normal integrity of action in the long axis of the foot: the result of course being constant lateral pressure on the toes (Fig. 212).

When this enlargement of the toe-joint assumes such proportions as to attract attention, the mechanical plan of treatment usually adopted is

FIG. 212.



simply the employment of a thick piece of leather having a hole in the centre, which is attached to the periphery of the enlargement; under the impression, of course, that the pad will receive the pressure tending to enlarge the joint, thus preventing a future increase. The least reflection will show how mischievous such a method of treatment must be; since, as the leather disc impinges upon the greater portion of the first phalanx of the toe, and the end of the metatarsal bone, whilst an open space is left at the joint itself, all force exercised by the boot *must* increase the malady, by tending to widen the distance between the already divided lateral margins of the joints. The idea of employing this disc as a remedial agent, doubtless originated in the notion that the surface of the joint would be levelled, and thus produce a reduction of the amount of pressure bearing upon it, but the results are undoubtedly the very opposite to this. Such an arrangement then is clearly erroneous.

There are two methods in which a bunion may be treated scientifically. In one, a slight trough of leather is carefully moulded to the internal margin of the foot, so shaped at its anterior extremity as to possess the direction which would be followed by the long axis of the great-toe, if in its normal condition. This should be attached to the instep by a strong though thin-laced band, a prolongation from which should pass around the heel, in order that the apparatus may be kept from slipping forwards, the extremity of the great-toe being carefully strapped within the trough. By this apparatus an action is obtained the very opposite to that produced by the disc of leather, or soap-plaster. The metatarsus, in this case, is a fulcrum, against which the lever which is to reduce the toe to its normal horizontal line can act powerfully, and all tendency of the boot, to press on and increase the bunion, is at once arrested; every encouragement being meanwhile afforded for the gradual absorption of the callous tegumentary portion of the deformity. This plan can be adopted with great success in slight and ordinary cases, but when the malformation is of long standing, it becomes necessary to employ a more complex and powerful apparatus. This consists of a delicate lever of steel, with a ring in its centre corresponding with the deformity at the joint. This lever is attached by a laced band to the instep. At the anterior and posterior margins of the oval ring is an ordinary hinge-joint, allowing the articulation to act freely in the natural plane, but calculated to oppose lateral tendency. The anterior portion of the lever is uniform in length with the toe, forming a spring the force of which acts inwardly * (Fig. 213).

When the great-toe is secured in this apparatus, that portion of the lever which is placed at the instep becomes the lateral fulcrum; the spring is the power, and the ring tends by its shape to approximate the separated lateral

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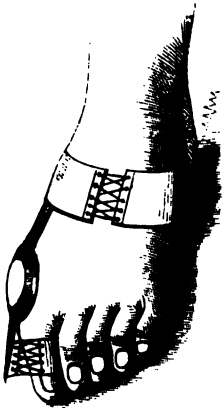
* The term inwardly must be understood to bear relation to the mesial line of the body.

FIG. 213.



margins of the joint. The preceding drawing explains the action.

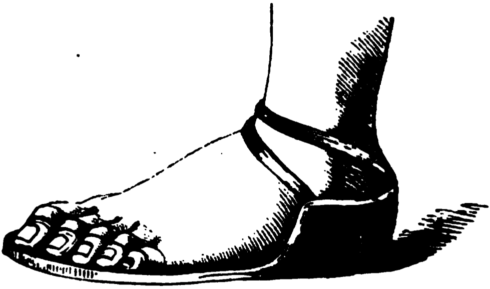
If carefully constructed, an ordinary shoe may easily be worn over this apparatus, and as the joints allow a free motion to the foot, walking is unattended with any difficulty.

It is a matter of much regret, that shoemakers cannot be induced to comprehend the necessity of so constructing their boots that a straight line may be drawn from the great-toe to the heel, and also that the *tread*, or distance allowed for the lateral play of the joints, is not made broader than at present. The boots would not lose in elegance, whilst the natural requirements of the foot would be better cared for. Another great evil which tends to produce bunions, is the adoption of an absurdly high heel for ladies' boots: the mechanical consequence of this being, that the plane of the foot no longer maintains its normal horizontal position, but is rendered oblique. The gravital line of the body, ceasing to pass through the centre of the foot, falls with unnatural and injurious force upon the phalangeal extremities, tending in this way to extend, and consequently weaken, their ligamentous attachments to the bones of the instep (metatarsus), and, as has already been stated, affecting the articulation of the great-toe in such a manner as to excite, sooner or later, the formation of a bunion.

Lateral expansion of the metatarso-phalangeal joints is not, however, confined to the great-toe alone; it also takes place, though rarely, in the little one. A mechanical apparatus, similar to that last described, or a leather splint arranged as for bunion, suitably adapted to the outer margin of the foot, suffices for the remedy of this deformity.

In addition to bunion there are certain contractions of the toes which require mechanical force for their relief. Prominent among these is the deformity known as "hammer-toe," which depends upon permanent contraction of the flexor muscles. In many of these cases a division of the tendons of the muscles principally affected is most valuable as an aid, and in some cases it is necessary, to the mechanical treatment. In slight cases of "hammer-toes," it will generally be found that the deformity may be overcome, and the toes extended, by mechanical means solely, provided that the appliance used be properly devised and carefully adjusted. The chief point for attention, in all cases, is the exercise of care in making pressure upon the knuckle or superior angle of the contracted joint, leaving sufficient space in the front of the apparatus to allow the distal phalanx of the toes to travel forwards, while the joint is being gradually extended. For the extension of a toe which is simply contracted at the second and third phalanges, I generally construct a well-padded shoe (Fig. 214), perforated with long slits corresponding to the inter-digital spaces; through these apertures pass small strips of webbing, which enclose the toe, and the tightening of which on the under surface of the

FIG. 214.

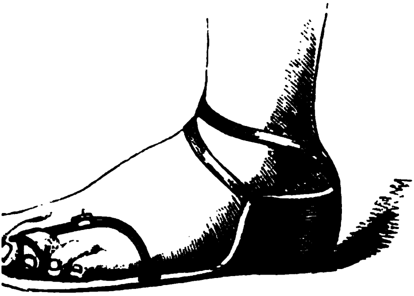


shoe necessarily extends the contracted joint, and lengthens the foot by stretching the tendons of the contracted muscles.

The same appliance, tenotomy having been had recourse to, will be found equally available in severer cases.

When a single toe is affected, and the contraction is severe, a different mechanical arrangement may be adopted. A small steel socket is fixed to the metal sole-piece of a Scarpa's shoe (Fig. 215), on that margin which corresponds to the contracted toe. This socket has its direction transverse to the toes, at their metatarso-phalangeal articulation. Into the socket is fitted a metal stem, so shaped as to arch over the toes until it arrives at the metaremity of the one which is contracted.)int it is joined by a second lever, which line with the long axis of the toe, and ›d to it by a tangential screw joint; m the distal extremity of this second 'e is a small strip of webbing, which ıeath and confines the toe. By means rew, we are enabled to raise the lever, at the same time bring the toe into its)sition. Uplifting of the anterior part)t, in lieu of the toe or toes, is effec- ›vented by two dorsal straps, which ıre the instep to the shoe. The reason ing the arched lever to the shoe by a that it admits of being more readily)osition after the shoe has been carefully) the foot.

FIG. 215.



I may add, that in very severe cases the lever can be furnished with a tangential screw for each joint, in which case care must be taken to make every centre of articulation coincide with that of the corresponding axis of the lever.

II. DEBILITIES.

Under the head of debilities of the lower extremities are included:

1. PARALYSIS OF THE LEGS.
2. RELAXATION AND DISPLACEMENT OF THE HIP-JOINT.
3. KNOCK-KNEES.
4. FRACTURE OF THE PATELLA.
5. SPRAINS.
6. VARICOSE VEINS.

Gymnastics of the lower extremities.

1. *Paralysis of the legs,* may be either partial or general. It may affect one or both limbs, and may be confined mainly to certain groups of muscles or may affect all equally. Most commonly it is partial rather than general, and

it attacks the extensor rather than the flexor muscles.

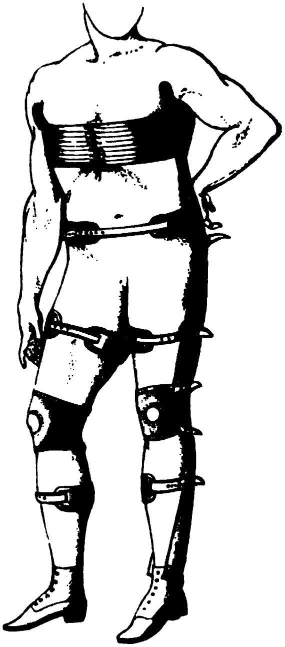
To what extent can the lost power of the muscles be supplied artificially? This is a question for the orthopractic mechanician to solve, and he has shown that the action of a paralysed muscle, or a group of muscles, may be simulated. He constructs artificial muscles from india-rubber, and infinitely as the substitute falls behind the organ imitated, it affords a means of relief from many and serious inconveniences which otherwise would be irremediable.

To render these substitutes effective they are attached to a species of external skeleton formed of articulated levers.

In paralysis of both extremities these levers are so arranged as to support the entire weight of the body. They have joints corresponding with those of the hip, knee, and ankle, and at each joint a strong vulcanized cord is affixed, giving stability to the whole of the mechanism, and yet admitting of articular motion. The apparatus when complete has the following appearance (Fig. 216).

Two lateral crutches, passing beneath each arm, sustain the weight of the chest and upper ex-

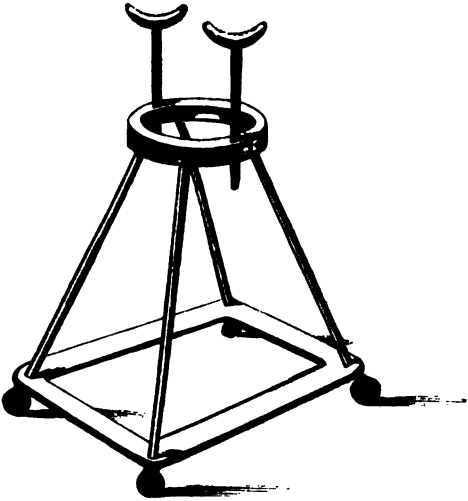
Fig. 216.



tremities, whilst the hips are held by a padded pelvic band. To the lower edge of this band an articulated lever is affixed, which, passing down the outer side of each limb and entering the heel of the boot, conveys the weight of the entire body to the ground. At the knee, ankle, and hip-centres india-rubber cords are fixed, so arranged as to admit of being rendered stronger or weaker at the will of the patient. These exercise extending power upon the limbs, and tend to encourage movement in a forward direction. The india-rubber ankle-strap lifts up the toes and prevents the feet from dragging upon the ground, as is usually the case in paralytic patients. Owing to the elasticity of the cords the patient can bend the knees and hips most freely, but in so doing muscular tension is excited. Thus not only does the apparatus support the body, antagonise the abnormally strong muscle, and assist progression, but it encourages muscular development by inducing action in those muscles which are preternaturally weakened. When the form of appliance is aided by a go-cart the patient can move from room to room and gradually discipline the weakened structures until some degree of strength is restored to them. The form of go-cart required in severe cases, as an adjunct to the apparatus just described, is made as follows (Fig. 217).

It consists of a padded wooden ring supported at a convenient height on a broad square base, and carrying movable crutches. The base rests on wheels, and the crutches can be raised or lowered as required.

FIG. 217.



The patient being placed within this apparatus attempts to move each leg forward in turn, the effort of doing which is sufficient to propel the go-cart onwards and thus facilitate the exercise of the limb. After a short period the legs get sufficiently accustomed to the appliances to act without the need of the go-cart, when a hand-stick can be substituted, and eventually even this may be discarded.

By the plan of procedure described it will be perceived that the ankle elastics simulate the action of those muscles which raise the foot. The knee elastic represents in action the extensors of the leg. The elastics of the hip act like the erectors of the spine and gluteal muscles, thus keeping the trunk supported and the thigh strengthened.

In this arrangement it must always be borne in mind that the purpose of the mock muscles is to supplement *not* supersede the action of the natural muscles.

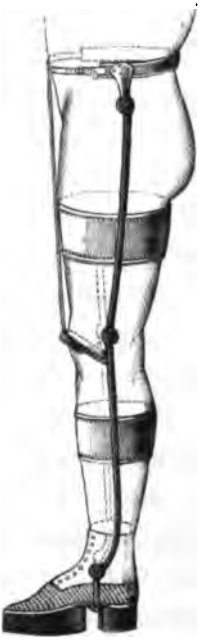
This mode of mechanical assistance is so valuable in the treatment of paralysis of the lower extremities, when the muscles are not rigid, as always to be worthy of trial, especially in conjunction with therapeutic means, such as galvanism, frictions, cold douches, &c.

Paralysis may, however, affect only one group of muscles, or even a single muscle. In this case there are special forms of appliances constructed to meet the exigencies of the case. For instance, should there be loss of power in the extensors of the leg and flexors of the ankle, as is very constantly found in young children who have had a paralytic seizure, the kind of mechanical treatment indicated is such as would induce increased activity in the weakened muscles, and at the same time give sufficient support to the whole limb to enable the child to stand upon it.

In almost all cases of infantile paralysis, when one leg only is affected, there is a certain amount of arrested development, in consequence of which the affected limb becomes structurally shorter than the other. A patient so circumstanced has a painful limp even when able to walk. The foot falls downwards, the ankle yields inwards, the knee bends forward, and the whole limb is brought in advance with much awkwardness and difficulty. Occasionally these symptoms are embarrassed by the presence of a relaxed condition of the muscles and ligaments of the hip-joint, which are not so much paralysed as debilitated from want of action. To remedy this state of things I have always applied an instrument which, having a fixed point around the hips, passes down to the ground by means of an articulated lever, which terminates in the heel of the boot. At the knee- and ankle-joints, vulcanized india-rubber cords are attached, the resilience of which can be regulated by a buckle and strap. The office of the elastic cords is to uplift the toes and throw the lower leg forward. Across the centre of the knee an arc of steel is placed, having also an india-rubber cord which fastens to the pelvic band, and when so fastened tends to throw the thigh forward and thus facilitate progression. Finally there is a high-heeled boot compensating for the loss of length and restoring the pelvis to its horizontal position, thus preventing the production of spinal curvature, which would, unless this precaution were adopted, most certainly ensue.

The form of instrument will be better understood by reference to the following drawing (Fig. 218).

Fig. 218.



The pelvic band gives stability to the hip-joint, in aid of which object a soft pad is placed beneath the axis of the instrument at this point.

A few months ago I was consulted by Mr. Barnard Holt upon the form of mechanical appliance which could be suggested for the relief of a case of adult paralysis affecting the right leg. The patient was a young lady of considerable attraction and public importance, and it was felt imperative to use every possible means for neutralising the ill effect produced by so useless a limb as she unfortunately possessed.

Many apparatuses had previously been tried in America and on the continent without success. On examining her case I found complete paralysis of the anterior muscles of the whole leg, thus causing, whenever any attempt was made to walk, dragging of the foot against the floor, anterior yielding of the knee-joint, and a jerking forward of the whole limb, due to the action of the lumbar and gluteal muscles, more especially of the region opposite to the affected limb. There was also considerable obliquity of the pelvis. An attempt had been made to relieve the latter evil by a clumsy cork boot attached to the instrument she was then wearing.

Although exquisitely proportioned the affected limb had become slightly reduced in size, but owing to the efforts made by the aid of mechanical agents to compensate for the loss of muscular power the diminution was less than might be expected. No natural ability to raise the foot or steadily advance the lower limb existed, whilst there was evident laxity of the hip-joint.

After my examination I felt convinced that both legs were in reality the same length, and that the apparent shortening arose from obliquity of the pelvis induced by the unscientific means hitherto taken to support the leg. Further, it occurred to me that if any means could be devised for borrowing the strength of the left limb and transferring it to the weakened right one, the pelvis might be restored to its normal plane, and also that the same borrowed strength might be utilised for giving power to the paralysed leg.

Acting on this idea, I constructed an instrument which enveloped the centre of the thigh, and had two articulated levers carried down to the sole of the boot, but where these joined the boot I adopted a peculiar arrangement. The levers were there curved forward in such a manner as to fasten to the centre of the sole, my object in so doing being to increase the leverage between the ankle-joint and the sole of the boot, thus compelling the toes to uplift themselves by the mere effort of gravity, the whole foot being suspended on a centre corresponding with the middle of the sole. A band similar to that of the thigh enveloped the calf, and from the sides of this band two vulcanized india-rubber cords passed upwards to the thigh, thus giving extensor power to the leg. There were also two vulcanized cords acting at the ankle-joint, and assisting the curved levers in raising the foot from the ground. But the most important feature of all was the method by which the strong leg was made to sustain the weight of the weak one and aid in its action. This I accomplished after considerable thought and many experimental trials, by fixing across the front of the knee a curved steel rod having several holes along its centre, and to these I hooked three vulcanized cords attached at the other extremities to a pelvic band, which I now proceed to describe.

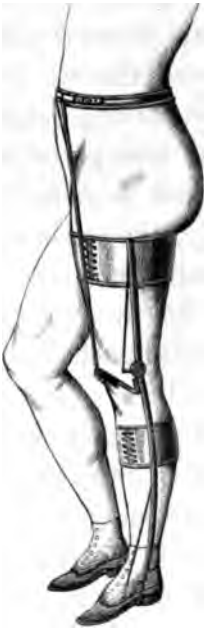
Finding that the young lady possessed a well-developed gluteal region I prepared a padded leathern strap cut in such a shape as to present a bifurcated extremity at the left hip. One of these bifurcations buckled to the ordinary and opposite end of the strap, thus completing the pelvic circle, whilst the other hung loose and ready to receive the three vulcanized thigh cords already mentioned. On attaching these the whole weight of the paralysed leg and its apparatus instantly hung upon the left and stronger side, and the least muscular movement rendered the mechanism almost automatic. The action of the apparatus, moreover, as I anticipated, restored the level of the pelvis and did away with the need for wearing a high-heeled boot.

When completed the young lady could walk easily with hardly any limp or dragging of the foot upon the ground, or exhibiting any impediment beyond the circumstance of its being impossible to give the same vitality in action to the paralysed as the normal leg. I, however, firmly believe that in a couple of years' time, with proper perseverance on the patient's part, almost all trace of lameness will have disappeared.

This piece of mechanism is depicted in the drawing (Fig. 219).

The curved ankle-stem is seen to rest under the sole of foot, thus helping the heel to descend, whilst the elastic cords urge the foot forwards.

FIG. 219.

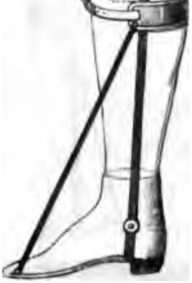


Across the knee the steel arc receives the india-rubber cords from the opposite hip, and thus transfers the whole weight to the pelvis on its left or strongest side, and at the same time carries the whole leg forwards. India-rubber cords at the knee-joint also facilitate this action.

Probably, no case ever offered so many difficulties as this did, but by perseverance they were all overcome.

Paralysis of the *tibialis anticus* is frequently met with and proves, after division of the tendo-Achillis, a most troublesome obstacle to the success of that operation. Hence it by no means unfrequently follows that after a foot has been restored to its proper shape and position, absence of power in the anterior muscles will permit it to drag along the ground, and thus seemingly negative the advantage of the operation. To prevent this unfortunate result, a very simple form of appara-

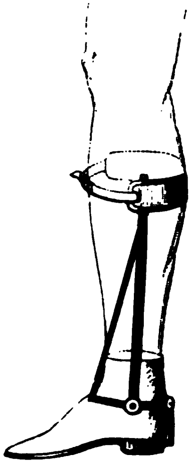
FIG. 220.



tus is needed. It consists of a lateral steel rod, which is fastened by a calf-band to the leg, is jointed at the ankle, and is furnished with a vulcanized india-rubber band extending from the calf-band to the toes—an artificial *tibialis anticus.* This mechanism (Fig. 220), by its action, uplifts the toes, and prevents retraction of the tendo-Achillis, whilst it also exercises the weakened anterior muscles.

When the peronei muscles are paralysed as well as the tibialis anticus, another form of instrument is to be adopted (Fig. 221). In this arrangement, the leg-stem terminates at the ankle in a

FIG. 221.



lever, which is attached behind to the boot. A vulcanized india-rubber cord extends between the calf-band and the anterior extremity of the lever, and serves while raising the toes to abduct the foot.

2. *Relaxed hip-joint.*—Amongst the affections of the lower limbs properly included in the category of debilities, may be mentioned a loose condition of the hip-joint due to relaxation of the capsular ligament. This is characterised by an abnormal mobility of the joint, sometimes conveying the impression that the patient is walking upon yielding clay. Where the relaxation is very slight, such as generally occurs in young children, the femur is readily held in its true position by mechanical pressure applied against the external trochanter from behind forwards; for, from the expanded shape of the alæ forming the sides of the pelvis, displacement backwards more frequently occurs than either upwards or forwards.

It can readily be understood that where weakness of the articulation exists any force calculated to resist osseous displacement must give stability to the whole joint, and thus secure the object mechanically undertaken.

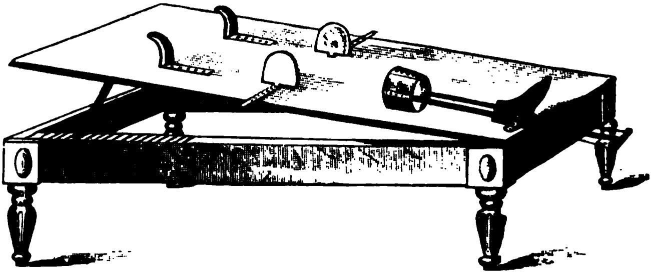
The instrument for effecting this end, consists of a pelvic band with a lateral crutch and thigh stem somewhat similar in form to Fig. 121, but, in addition, it possesses a padded plate fixed immediately beneath the artificial hip-joint, and acting by means of a small screw in such a manner as to throw the head of the thigh bone forwards into its cup and keep it there. There is also a leathern band fastened to the opposite thigh to prevent displacement of the instrument, which would otherwise turn round upon the pelvis from the pressure offered by the hip-bone.

More than one form of appliance has been devised for the relief of *luxation of the hip-joint* not arising from accident. This deformity may affect either one or both hips, and may vary in extent from partial displacement of the head of the femur to its entire removal from the acetabulum or cup, and the formation of a new socket on the ilium. Where the case is so severe that entire displacement of the head of the thigh bone has taken place, considerable shortening of the affected limb results.

A little time ago I saw a Russian child whose right hip had escaped from its socket, giving rise to a decrease in length between the two legs of nearly five inches. The mechanical means adopted in this instance consisted of a padded couch, which I designed, and upon which the child rested day and night for three months, during which period the shortened leg was gradually brought to the same length as the other, and the head of the femur restored to its natural position. The couch consisted of an inclined surface covered by a soft mattress three inches thick, having an aperture for defecation. Two sliding crutches were fixed to this couch on which the child's arms rested, whilst the pelvis was firmly grasped by two padded plates acting laterally by means of horizontal screws. A padded strap passed around the opposite leg and under the perinæum of that side, thus securing a fixed point for future extension of the limb. Around the thigh and calf of the affected leg straps were placed communicating with a padded steel shoe in which the foot rested. To the sole of this shoe was fixed a powerful screw acting against a standard fixed in the lower edge of the couch. When this mechanism was carefully applied, gentle extension was induced by turning the screw belonging to the sole-plate; this being repeated daily until the leg was brought into its proper position, when a splint made of moulded leather served to secure the hip-joint permanently in its socket.

I believe this to have been the first couch of the kind ever employed for the purpose. I have since, however, constructed a similar couch for a patient of Mr. Brodhurst with highly satisfactory result, so far as extension was concerned. Not having personally seen the case for several months, I do not know whether Mr. Brodhurst has been able to secure the final advantage aimed at, viz., that of permanently securing the hip-joint in its proper place, which is, of course, the great object to secure.

FIG. 222.



A somewhat similar case to that of the Russian child was sent to me a short time ago by Mr.

Jones, of Leamington; and acting upon his suggestion, I applied a very strong and deep pelvic belt, having at its side a metallic rod and padded steel thigh-band. Just above the external trochanter a thick semi-lunar pad was affixed, governed in such a manner by straps attached to the steel rod, as to force downwards and inwards the head of the femur. This succeeded in enabling the patient to walk with freedom, whereas previously he had the utmost difficulty in moving at all.

3. *Knock-knees* (*Genu-valgum*).—This deformity is primarily referable to a relaxation of the internal lateral ligaments, which, by permitting the superior and inferior extremities of the tibia and femur respectively to become slightly separated at their internal lateral surface, disturbs the axis of the joint (nearly horizontal), and gives rise to an angular obliquity of the bones. This angular condition is increased by the superincumbent weight of the body. The object, therefore, which is most aimed at in the construction of every variety of apparatus intended for the treatment of this distortion is the restoration of the leg and thigh to a vertical position by bringing the knee-joint into its original condition.

When occurring in young and growing children, this variety of distortion is attended with very grave consequences, inasmuch as it rarely happens that both legs yield in the same ratio or present the same angle of inversion. This being the case, it follows that the pelvis becomes oblique on the side of the shortest leg, and a curvature of the spine is established, having its arc of dorsal curvature on the side opposite to the shortened limb.

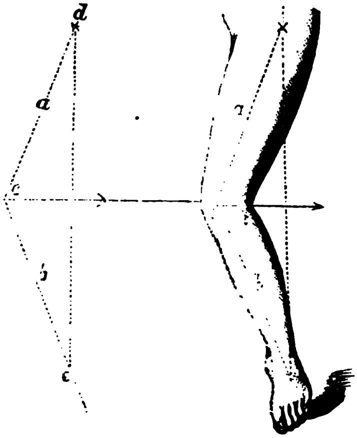
The mechanical treatment of knock-knees is by no means so simple as would at first sight be supposed, and for the following reasons:—The deformity involves a disturbance of the normal perpendicular position of the entire leg, resolving it into an angle composed of two levers. The first and shortest of these, the thigh, is joined to the pelvis, its centre of radiation; the second, the leg, apparently radiates from the knee-joint, although, as I shall presently demonstrate, it deflects from a different point.

In order that the apparatus may act upon the knee-joint with the greatest economy of force, one extremity must be attached to the pelvis, the other to the heel of the boot. Taking these two points, then, as the centre of circles, which cut one another at the centre of motion in the knee-joint in "genu-valgum," but only *touch* at this point in the normal state of the limb, from which the thigh and leg respectively are as distinct radii to these points in their peripheries ; it is manifest that when these radii, or levers, are not in the same straight line, as is the case in the distortion under discussion, the centres of the circles must be brought nearer to one another, so that the line joining them would be as the base of a triangle. Now, by applying power to the inner surface of the knee, the apex of the angle formed by the thigh and leg, we compel these radii to move in an outward direction, lengthening the base of the triangle, and increasing the distance between the centres of the two circles ; *bringing the radii into such a position, that their centres of rotation, and the levers themselves, shall have become coincident in one and the same straight line.*

Carelessly viewed, it would appear, from the great distance intervening between the two feet, that the end of the femur must become a fixed point of rotation for the tibia ; but I believe that the ground should be looked upon as one centre, the pelvis another ; the superincumbent weight of the body being an applied power, which induces lateral movement in the two levers —hence the deformity. The distance between the feet is referable to the fact that they must accommodate themselves to the obliquity of the femur and tibia, which results from the whole angle being thrown outwards from the pelvic centre. I was principally led to hold the opinions which I now advance, from having often observed, that upon the application of an apparatus to these cases, the rectilineal form of the instrument became an unchangeable base, the leg and thigh mutually conforming themselves to the plane of direction; thus clearly proving, that the heel of the boot and the hip-joint are the two points whence the femur and the tibia rotate inwardly, as will be seen by the following diagram (Fig. 223).

If my reasoning be valid, the necessity of treating "genu-valgum" by almost entirely suspending flexion of the knee-joint is at once decided in the affirmative; for when the leg bends in an anterior direction, a large amount of lateral traction is at once lost, through the disposition manifested by the apparatus to inward rotation at the pelvis, and the consequent destruction of the plane of inversion.

FIG. 223.



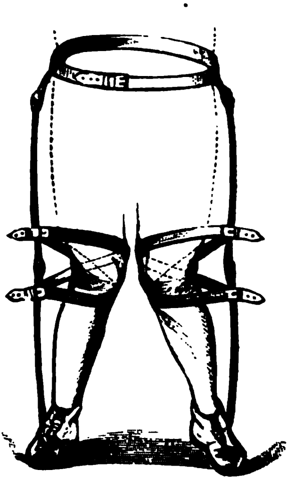
a. Is the upper or femoral lever.
b. The lower, or tibio-tarsal.

When power is applied at *c*, the levers *a* and *b* move in an outward direction; their several centres *d* and *e* moving upwards and downwards respectively.

In cases of simple ligamentous weakness, instruments furnished with knee-joints are very useful, as they aid in sustaining the perpendicular position of the limb; but where there is deflexion to any serious extent, nothing will be able to overcome the deformity but an apparatus without joints, save at the hip and ankle, and which extends from the pelvis to the ground.

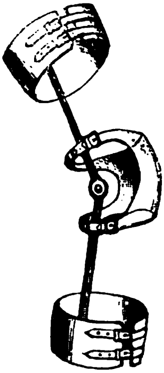
I proceed to a description of various instruments which are used in the treatment of this malady; commencing with such as are constructed with articulated levers.

FIG. 224.



In the first (Fig. 224), two lateral stems, with ankle, knee, and hip-joints, extend from the heel to the pelvis, each being secured at its upper extremity to a padded pelvic band, which encircles the body; at the lower, to a tubular socket in the heel of the boot, and to the leg, by two padded straps, one of which arises from the thigh-stem, and is fastened in front to the lowermost stem, after having crossed from behind over the inner condyle; the second, which likewise passes round the back of the knee over the condyle, being secured to the upper strap. Thus they act crosswise; the upper strap contributing to support the head of the tibia, and the lower one that of the femur—their combined direction of force being *outwards.*

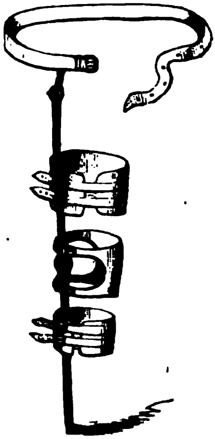
Fig. 225.



This instrument is exceedingly light, and, as it admits of free muscular motion, answers admirably in ordinary cases.

The second kind of instrument (Fig. 225) is also furnished with a knee-joint; but, instead of being attached to the pelvis, it terminates *above,* at about the middle of the thigh, and below, at mid-calf, by two padded bands. The knee itself is supported by a strong knee-cap, which is fastened to the thigh and leg-levers; the principal advantage of the apparatus being, that it can be entirely concealed by the dress, hence, when a lady is under treatment for "knock-knees," this instrument can be worn without attracting notice.

FIG. 226.



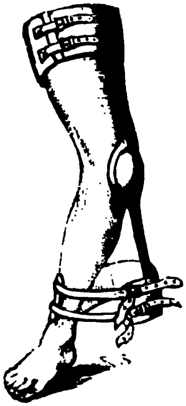
The third form (Fig. 226) of articulated apparatus is nothing more than a slight modification of the one first described; but instead of using two straps as tractors, a knee-cap is substituted. Another point of difference is, that the leg and thigh are acted upon by padded metal bands, which surround each, and greatly diminish the loss of mechanical power attendant upon kneeling, when an instrument is secured to the leg by straps alone. This is probably the best of all the articulated leg instruments which are used in the treatment of "knock-knees."

This instrument is likewise furnished with a joint coincident with the axis of the ankle, and the boots are firmly riveted to it, instead of being placed in a tubular socket; so that when the apparatus is applied, it fits closely to the limbs. It will readily be seen, that when the shafts of the leg and thigh are grasped by the upper and lower bands, a great control must be gained over the lateral deflexion.

I have next to describe an instrument constructed upon a principle which is open to considerable discussion. It was invented by Mr. Hester, of Oxford, by whose instructions I applied it, with very promising results, to a patient of his, about four years ago. I have had no other opportunity of trying this kind of appliance, and on this account refrain from hazarding an opinion as to its probable efficacy in ordinary cases. It is constructed upon a theory, "that the lower part of the leg (tibia and tarsus) rotates from the inferior extremity of the femur, in an outward direction, and that the thigh always holds its original and perfect position." I have already stated, that I am convinced that the femur and tibia become mutually oblique in the formation of genu-valgum; still, I am bound to admit that, supposing the action which I am about to describe be successful, the obliquity of the thigh may be overcome by the application of an instrument to the *inner side* of the leg, consequently inducing an increase in the space between the internal condyles, with reduction of the femoral obliquity. The instrument (Fig. 227) is constructed of two levers, with a large hollow-jointed disc at their point of junction, which receives the internal condyle within its circumference. Of these levers, one corresponds with the *proper* line of the thigh, the other, with that of the leg, and both terminate by padded metal bands, those above surrounding the thigh, those below the calf. When the upper stem is fixed firmly to the thigh, a space is left between the inferior extremity of the lower stem, and the internal malleolus of the tibia, proportional, of course, to the angularity of the limb; which space must be reduced by fastening the lower padded band as tightly as the patient can bear it.

In the mechanical action of this instrument, the thigh lever becomes a fixed point, its major fulcrum being situated at the inner condyle;

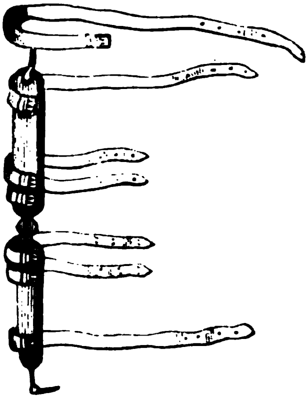
FIG. 227.



while, as the resistance to be overcome is afforded by the lower leg, the calf-band presents the required means for reducing the space between the tibia and leg-stem. Kneeling can be performed at pleasure during the whole period of treatment, the knee-disc forming a ring-joint.

In the next class of instruments, the knee-joint is held in a fixed position. The simplest of these consists of a long padded splint (Fig. 228), extending from the greater trochanter to

FIG. 228.

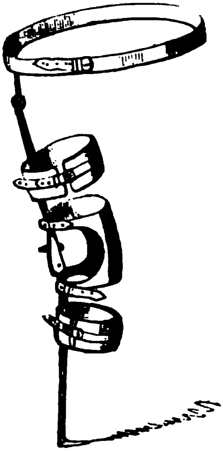


the heel of the boot, where it fits into a tubular socket. The upper part of this splint is fixed to the body by means of a hip-joint in a padded pelvic band, and the angle formed by the leg and thigh is gradually reduced by the pressure of a strong and broad webbing strap, which surrounds the knee. In the Orthopædic Hospital, these splints are rarely attached to the boot; consequently they lose much of their efficacy by rotating upon the limb.

I am indebted to Mr. Cæsar Hawkins for an admirable modification of this instrument. It consists in placing a stop-joint at the knee, so arranged as to admit of the splints being flexed to such an extent as will enable the patient, when walking, to throw the legs forward without causing rotative movement at the hip-joints. Of course this is accomplished by not permitting the flexor action to extend further than will just suffice to clear the foot off the ground, without weakening the lateral mechanical traction of the apparatus. I have also added a screw, turned by a key in such a manner, that the angle of flexion can be increased or decreased at pleasure.

In the next appliance (Fig. 229), based upon the foregoing principle, a padded pelvic band has attached to it a perpendicular lever on each side, which passes down the outer side of the leg, and is furnished with free centres at the hip and ankle-joints; that at the knee, however, being fitted with a tangential screw, the axis of which being rectangular to the leg, permits extension only in the plane of the leg's inversion. The thigh and calf are surrounded by padded metal bands, which are fixed to the lateral stem. When this instrument is applied, the ratchet-joint should be made to correspond, in its direction and degree of angularity, with the inverted knee; and as the knee itself is firmly grasped by a broad band of webbing, whilst the calf

FIG. 229.



and thigh are held by the metal bands, the extension of the knee-screw *outwards* produces a pressure upon the pelvis and heel, together with a diminution of the angularity of the knee by depression of its apex; and the leg will gradually regain a straight form, by being drawn parallel with the external levers, or leg-stems.

Every principle essential for the treatment of knock-knee will be found embodied in the foregoing apparatuses; it is desirable, however, that some idea should be given as to which is the best in particular instances of this distortion. It has been found from long experience that the instrument described at page 600 is the most efficacious in simple cases; that at page 606 in severer cases; that at page 608 in the severest.

When lateral inversion has proceeded to that point, where the line of gravity no longer coincides with the perpendicular, or normal, centre of the limb, contraction frequently results in a posterior direction, this being the compensation afforded by Nature towards the sustentation of the bodily weight within the area of the foot. In this case, the deformity must be treated on a plan differing from any of those which have hitherto been suggested—viz., the angular contraction of the knee in its mesial plane must be overcome in the first place, and then the lateral inversion. The mechanism for accomplishing this is but a modification of the apparatus last described, the only difference being, that instead of one, there are two ratchet-joints at the knee, the axes of which are rectangular to each other; thus the one ratchet-wheel extends the leg from the thigh, while the other overcomes the inversion.

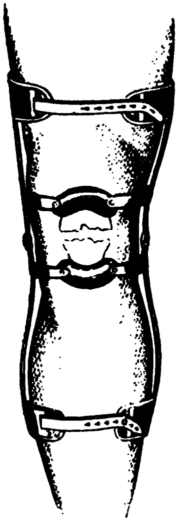
4. *Fracture of the Patella.*—Although injuries

resulting from fracture hardly fall within the scope of orthopractic art, yet one variety may claim exemption from this general rule on account of the necessity there is for possessing a perfectly constructed mechanical appliance in order that its treatment may be successfully undertaken. Where the fracture is recent, a piece of gutta-percha accurately moulded to the limb and furnished with two semi-lunar pads, the marginal concavities of which grasp the superior and inferior fragments of the patella, and thus secure such apposition as shall favour the formation of cartilaginous junction, is the usual appliance; and even in cases of some months' duration this form of splint has been often adopted with success, as I have recently seen illustrated in a case under Mr. Lawson's care, at whose suggestion I constructed a splint of the kind just named, which at once removed pain, and gave power to the patient's knee.

It is, however, more with cases of old standing and disunited fracture that the orthopractic mechanician has to deal. The features presented by a case of this kind are separation of the fractured portions of the patella, laxity of the quadratus femoris muscles, and an inability to stand long on the limb without its suddenly yielding beneath the patient's weight.

To overcome this last condition and impart security to the limb is the object of the following instrument (Fig. 230), which not only secures the patella, but by limiting the angle of articular motion prevents the possibility of an accidental fall.

Fig. 230.



The apparatus consists of two lateral steel rods articulated in such a manner as only to admit of a very limited amount of motion in the joint. These are secured to the thigh and calf by padded metal bands, whilst two straps holding semi-lunar pads pass over the front of the knee and prevent displacement of the patella.

5. *Sprains.*—(*a.*) *Sprain of Gastrocnemius.*—Occasionally the large muscle which forms the calf is sprained, and its minute fibres ruptured, leading to an extremely painful condition and consequent lameness. The mechanical remedy for this injury is a padded slipper, secured to the thigh by a band and strap. The object of this arrangement is to keep the heel from depression and give rest to the fibrillæ which compose the belly of the muscle. This mode of treatment generally succeeds in restoring strength and usefulness to the leg; but should it not do so, an elastic stocking composed of silk and india-rubber can be used, and the heel of the boot raised a couple of inches.

(*b.*) *Sprain of Ankle-joint.*—The ankle is exposed to many more chances of sprain and local injury than any other articulation, not even excepting the fingers, in consequence of the important part it plays in locomotion. In order to guard against ordinary accident this joint is strengthened by powerful ligaments, whilst the manner in which the component bones are articulated protect it greatly from injury. Powerful tendons prevent much mischief happening to this joint in its ginglymoid plane of movement, but in its lateral plane the resistance offered is not so considerable; hence the frequency with which this joint meets with accidents. When the sprain is simple in its character rest and an elastic sock are sufficient for restoration, but when a more marked degree of injury is present then the mechanical means adopted are a laced boot with stiffened sides, so as to preserve the normal integrity of the joint, and, added to this, a light metallic rod articulated at the ankle, and giving such support to the lateral ligaments as to prevent them again becoming extended or strained. In shape this appliance resembles Fig. 196.

6. *Varicose veins.*—Another affection of the lower limbs due to debility or weakness is that known as varicose veins. This condition originates in some impediment to the flow of blood from the lower extremities, and a lax state of the parietes of the veins.

Varicose veins are not, however, strictly confined to the lower extremities, but may exist in any other part of the body where obstruction to the venous circulation exists. Wherever they may happen to be, the mechanical means required for their treatment consists in the application of a silken elastic support, formed principally of india-rubber, to the varicose region; hence in the leg this takes the form of an elastic stocking, knee-, ankle-, or thigh-bandage, whilst in the trunk it has the shape of a belt or stays.

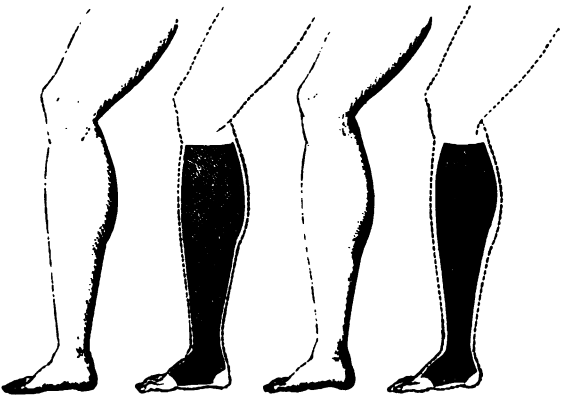
Elastic bandages should always be constructed of the precise form of the region for which they are required; hence the custom of purchasing these appliances at the first druggist's or draper's shop that may happen to be near is most mischievous.

The object in these appliances is to give a uniform support to the part affected, but this is rendered impossible if an accurate fit is not obtained.

From the highly elastic material of which these articles are composed, it will be understood that great latitude is taken by manufacturers and shopkeepers in adapting them to a limb. If the retracting surface acts unequally, isolation of some parts of the varicose veins is apt to occur, whilst the adjacent regions may be tightly compressed.

The annexed diagrams (Fig. 231) represent the right and the wrong way of applying elastic stockings. I do not know anything demanding more care and where greater carelessness exists than in the application of elastic bandages. In this respect the clumsy and old-fashioned laced stockings are constantly resorted to where uniform pressure is highly desirable.

FIG. 231.



The above drawings are no exaggeration of the effects of hap-hazard selection in accordance with linen-draper's sizes. It is a matter of surprise that this subject has never excited the attention it deserves, more especially when it is remembered that upon the accurate fitting of such appliances, the proper circulation of the blood and the absorption of abnormal secretions so frequently depend.

Supports for varicose veins are of three kinds:

1st. The old-fashioned laced stocking, composed of thick jean and india-rubber, with a series of lace-holes to attach it to the leg. This form of support, in cases where the skin is broken or otherwise injured, is still adopted as the best means of affording support.

2nd. Stockings of a reticulated or net-shaped substance in which fibres of india-rubber are interwoven in a direction transverse to the vertical plane of the limb.

3rd. Stockings constructed on the spiral or helical principle; which consists of long strips of delicate elastic web sewn together in a spiral form. This plan was invented by an ingenious Frenchman named Bourgeard.

It may perhaps be a matter of interest to know that the first bandage entirely made of elastic fabric was constructed and applied by myself to the Duke of Buccleugh, for whom Sir A. Cooper was anxious to obtain some appliance more easily adjusted than the ordinary lacing bandage. The fabrication was, however, exceedingly crude compared with the exquisite and beautiful productions of the present day.

A plan of treating varicose veins by mechanical pressure was suggested to me by my friend Mr. T. Nunn. The value of this method is so great that I venture to mention it. It consists in the application, beneath an ordinary elastic stocking, of a small silken pad accurately following the course of the varicose vein, and thus by its localized pressure tending to approximate the venous parietes. I have seen several most successful cases resulting from this practice.

Gymnastics of the Lower Extremities.

This section has been in great part anticipated by the description of instruments for flexion and extension of the knee (pp. 455 and 459), flexion and extension, abduction and adduction of the ankle (pp. 545, 546, 548, 549), and rotation of the thigh (p. 432). These pieces of mechanism, specially constructed for the application of localized movements to the lower extremity, are admirably adapted for the purpose. They are more complex, however, than is requisite in many cases. Where the contraction is slight, a much more simple arrangement may be adopted. In such cases, indeed, with a pulley and a piece of rope it is not difficult to extemporise an appliance which will serve every useful purpose. In fig. 165 is shown one method of applying the rope and pulley which will be found valuable in several forms of contracted hip or knee, or as an aid to the exercise of imperfectly paralysed muscles of the thigh.

When, indeed, it is requisite to place systematically in action the paralysed muscles of the lower extremity, over which voluntary control is not altogether lost, a simple pedal attached to a weighted rope passing over a properly fixed pulley, or so arranged that it may be acted upon by graduated elastic cords, will serve every purpose. The weighted cord and pulley are most easily managed, and any ingenious carpenter can without difficulty construct a frame-work, movable or fixed, to which they can be attached. In hospitals, where it may be desirable to have a permanent arrangement of weighted cords for the exercise of paralysed extremities, whether upper or lower, the gymnasium already described (Fig. 129) would be found most convenient.

I proceed now to describe some of the less complex means of exercising the lower extremity by mechanical aid.

Contraction of the hip-joint.—This deformity requires a great amount of attention and care so perfectly to "localize" the "movements," that, whilst seeking to relax contracted muscles, no undue strain may be exerted upon the joint itself. I employ an apparatus consisting of a seat upon which the patient rests; his pelvis or hips are secured to this seat; a padded band surrounds the thigh, and three cords passing over pulleys properly fixed, bring the limb into motion. By the patient pulling one cord the thigh is extended; by pulling another, it is abducted; and by pulling a third, it is rotated.

All these motions are required in order effectually to overcome contraction at the hip-joint. This exercising apparatus, like all others, can be furnished with a "tell-tale," indicating the exact number of movements performed in each direction; and enabling the patient or operator to judge accurately of the extent to which the movements are carried.

Contraction of the knee-joint.—The localized exercises adapted to contraction of the knee-joint should be those which will particularly extend the tendons of the biceps, semi-tendinosus and semi-membranosus muscles, the contraction of these muscles being the principal impediments to flexion and extension of the knee-joint at the will of the patient.

The simplest exercise is performed as follows:—The patient being seated, the leg and thigh are secured to the seat by means of straps adapted for the purpose. A slipper is firmly fastened to the foot, and at its anterior extremity a cord is attached, communicating with a pulley, so fixed that, when the former is pulled by the patient, the leg is extended. An india-rubber band fastened to the heel of the slipper establishes action in the contrary direction; and thus gentle but continuous and well-regulated exercises may be employed for about half to three-quarters of an hour daily, until permanent extension of the contracted tendons and strengthening of the limb result.

In cases where the contraction of the knee-joint is slight, simple manipulations, accompanied by active and vigorous shampooing, are employed; but even in these cases, the use of the apparatus just alluded to is better than any other plan, owing to its possessing an index denoting the number of times the knee has undergone flexion and extension, thus permitting the amount of motion to be accurately ascertained. An exercise of this kind soon succeeds in extending the muscles belonging to the posterior part of the leg, when the case is slight; and also, where tenotomy has been previously resorted to, an increase of power and flexibility is undoubtedly obtained. In fact, such exercise should be the invariable sequence to surgical treatment, as affording the most certain method for permanently establishing its good effects.

When the patient is knock-kneed, then an exercise of a different kind may be adopted, in order not only to overcome the resistance offered by the muscles of the outer side of the leg, which are shortened; but, also, to diminish and eventually overcome the ligamentous opposition which invariably attends cases of knock-knee, when of long standing. The plan to be pursued is, first, to place the heel of the patient against a slight padded rest fixed to a stool, and then, by pressure, exercised by the operator's hand applied to the inside of the knee, gradually to induce the limb to assume a straight position. Added to this, shampooing, friction, and manipulation should be freely employed to the outer side of the knee-joint, while pressure is steadily maintained against the inner surface (inner condyle of the femur). After pursuing this plan vigorously, for a certain period, according to the age of the patient and the condition of the case, a padded splint should be affixed to the leg, in order to secure the advantage gained by motion.

It must be distinctly understood that in all severe cases of deformity, involving the inferior extremity, exercises and movements are merely adjuncts to mechanical treatment, in the restoration of the part to its normal state; and the reason why these exercises hold this secondary position is manifest, when it is recollected, that the weight of the body rapidly counterbalances whatever gain may have been obtained in the legs during "exercise." In these cases, very light mechanical appliances, calculated to maintain the rectification secured by movements, and yet to allow every natural bodily motion, are applied, after the exercises have ceased.

Contraction of the heel.—In slight examples, the foot is rapidly flexed and extended during a period of ten minutes; then the ankle-joint and its adjacent parts are well shampooed by the hand of the operator, thus leading to flexibility of the joint. In more aggravated cases, a like exercise is first employed for a period varying, according to the age of the patient, from five to fifteen minutes; and then the foot is placed in a leathern boot, having a small perpendicular spring affixed to it, the action of which tends to maintain the extension which is gained by exercise. In still worse cases, exercises are performed by the employment of a nicely padded slipper, affixed to a pulley. The patient is seated on a properly prepared stool, and commences by pulling a cord attached to the toe part of the slipper; the effect of which is to extend the heel-tendon. A strong india-rubber band, fixed to the heel of the slipper, opposes the traction of the pulley, and thus enables the patient to flex and extend the foot as rapidly as may be desired.

A small index can be affixed to the apparatus, by which the person who superintends the movements is rendered aware of the number of times the foot has been flexed and extended. This arrangement is most useful, because the success of the treatment is largely dependent upon the regularity with which the exercises are performed.

To facilitate the application of localized movements I subjoin, as in the case of the upper extremity, a synopsis of the mode of action of the different joints of the lower extremities. The movement of the joints represents the direction of action of the different groups of muscles, and forms the simplest guide to the passive or voluntary exercise of these.

1. *Hip-joint.*—This articulation permits—

(*a*) *Flexion.*
(*b*) *Extension.*
(*c*) *Abduction.*
(*d*) *Adduction.*
(*e*) *Circumduction.*
(*f*) *Rotation.*

In extension it is well to remember that the psoas and iliacus muscles fulfil the part of active ligaments. Hence, in extension, these muscles are brought into action.

2. *Knee.*—This joint admits of—

(*a*) *Flexion.*
(*b*) *Extension.*

It permits, also, slight movements of rotation.

3. *Fibular joints.*—The movement of the fibula upon the tibia is nearly imperceptible.

4. *Ankle and tarsal joints.*—The actions of these joints are best considered together, as they co-operate too intimately to be dissociated in the movements of the foot.

The *ankle-joint* permits chiefly and the *tarsal joints* slightly movements of

(*a*) *Flexion.*
(*b*) *Extension.*

The *ankle-joint* admits of very slight lateral motion, and the movements of

(*c*) *Adduction,*
(*d*) *Abduction,*
(*e*) *Rotation,*

of which the foot is susceptible, depend almost exclusively upon the articulations of the tarsus.

(*f*) *Circumduction*

arises almost entirely from the ankle and tarsal joints.

5. *Tarso-metatarsal articulations.*—The movements of these joints are very slight.

6. *Metatarso-phalangeal articulations.*—These joints permit the first phalanx of the toes to move in—

(*a*) *Flexion.*
(*b*) *Extension.*

(*c*) *Adduction.*

(*d*) *Abduction.*

7. *Phalangeal articulations.*—The movements of the phalanges of the toes are similar to those of the fingers, but much less extended.

III. Deficiencies.

The deficiencies of the lower extremity which the mechanician has to contend with are chiefly those which arise from accidental mutilation or from surgical operation. Occasionally he is called upon to relieve the disability which arises from a leg the development of which has been arrested. To effect this, a modification of one or other of the instruments described under the section of Deformities, will meet the requirements of the case.

When from accident or disease it has become advisable to remove by the surgeon's knife the whole or part of a lower limb, or this has been destroyed by accident, the first consideration influencing the patient's mind is, the probable effects of the mutilation upon the pursuit of his daily avocation.

Various mechanical substitutes have from the earliest times been devised for the purpose of supplying the place of an abbreviated lower member. Whatever their constructive form, the aim in all such pieces of mechanism is to afford a substitute for the defective limb. For this purpose the clumsiest apparatuses are occasionally resorted to. Such, for instance, as a mere rest for the stump, and a pin or stick to make up the interval between the stump and ground.

The true mechanician in constructing an artificial limb will seek to approximate it as nearly as possible to the mechanical condition of the natural member; and insignificant as this approach may be, even in the most ably devised mechanisms, in striving for it, such success as is attainable can be secured. And this success is at least such that the mutilated individual can, as a rule, be made equal to all the duties of an active life, while the defect of symmetry is diminished largely.

The first point which the mechanician has to consider is the nature of the stump. In amputation above the knee the length of stump best fitted for the adaptation of an artificial limb is two thirds of the thigh. If the stump be longer than this, the end may press against the sheath of the artificial limb to the great discomfort of the patient and impediment to free walking. In amputation below the knee, the length of the stump is of less importance. But if it be shorter than one third of the leg, difficulties are experienced in securing the artificial leg.

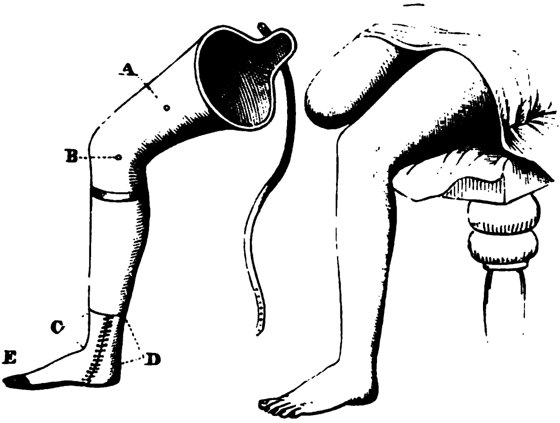
The length of the stump is, however, not always within the surgeon's control. Sometimes from disease or accident it is necessary to remove almost the entire, if not the entire limb. And an artificial member can be successfully attached to a stump of but a few inches' length, although the difficulty of satisfactorily adapting the substitute increases as the extent of surface for attaching it decreases.

An artificial leg above knee, when properly constructed, represents in external form the shape of the perfect limb, and corresponds in articular action. Its mode of attachment to the stump is by means of a sheath or "bucket," and the joints are brought into motion either by the action of the stump—as at the knee—or by metallic and other springs, as at the ankle and toe-joints.

Upon the fit of the bucket and accuracy of the joints depends the success of the mechanism. If the conditions required for its perfect construction are fully complied with, the form and action of the leg will differ but little from the sound limb; and cases have frequently occurred within the experience of the writer where detection of the false leg from the real by a casual observer has been a matter of considerable difficulty.

The following drawing shows the different parts of an artificial leg above the knee (Fig. 232).

Fig. 232.

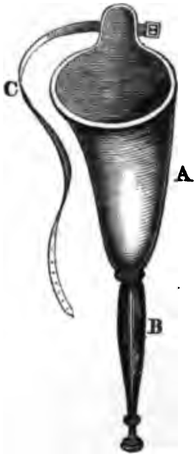


That portion of the artificial leg which receives the stump (A) is called *the bucket.* Upon the proper construction of this part entirely depends the action and stability of the remaining parts. Some time ago I discovered and applied a new principle to its formation, which, whilst it secured the most complete apposition between the stump and the artificial receptacle, required only *one* point of bearing in conformity with the internal anatomy of the limb. The *bolts* (the *knee-bolt* being shown at B) are the various articular centres required to fix the different parts of the artificial leg together and produce axial motion. The springs (C, D, E) are the mock muscles, or motors governing the action of the ankle and toe-joints.

An ordinary bucket leg (Fig. 233), such, in fact, as is usually made use of by the poorest people, is thus constructed. It consists of a hollow sheath or bucket (A) accurately conformed to the shape of the stump, and having—in lieu of the more symmetric proportions of the artificial leg—a "pin" (B) placed at its lower end to ensure connection between it and the ground.

This form of leg is strongly to be recommended where expense is an object, as it really fulfils all the conditions (excepting external similitude) embraced by a better piece of mechanism. It is

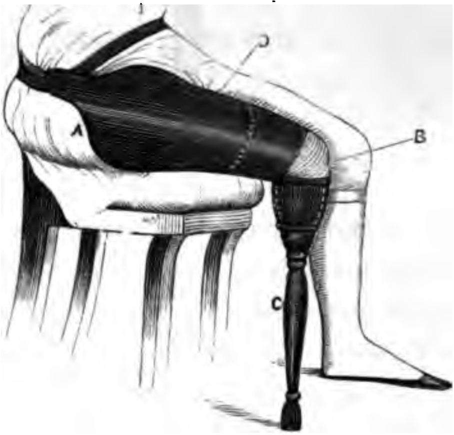
FIG. 233.



likewise occasionally employed with benefit by those patients who from lack of confidence prefer learning the use of an artificial leg by first practising with the commonest substitute.

There are fewer varieties in legs above knee than below, from the point of amputation rarely differing in the former, but admitting of much deviation in the latter. Thus, when a limb is lost above knee, the usual point for surgical removal is about the middle third of the thigh, the stump resulting having an almost universal form and length; but when the limb is amputated below the knee, it depends greatly upon the opinion held by the surgeon (as to the most advantageous stump) whether the remaining portion embraces nearly the whole of the tibia or terminates a little below the knee. Two kinds of leg above knee have been depicted; there is yet a third (Fig. 234) which possesses a certain amount of merit,

FIG. 234.



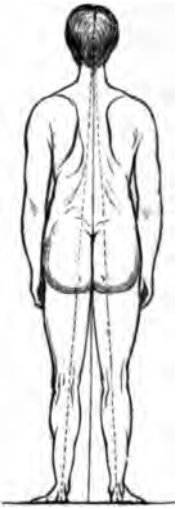
A, bucket; B, knee-joint; C, pin; D, lever uplifting rachet-catch at knee.

from being less expensive than a complete form of artificial limb, and more useful than the common bucket leg. It consists of a wooden stump sheath (A) furnished with a knee-joint, the action of which is entirely under the control of the patient, who can at will kneel, or keep the artificial limb rigidly extended. The mechanism employed is a vertical spring bolt and ratchet (B); the former situated at D in the figure, and acting upon the latter fixed in the knee-joint (B). The leg terminates in an ordinary pin (C).

The primary object sought in the construction of a substitute for the natural limb is to place the weight of the trunk on such portions of the artificial surface as are best enabled to assist locomotion without paining the stump.

If after amputation above knee a stump thinly covered by integument remains, and a mere bucket or hollow wooden sheath were adjusted, regardless of anything but conformity to external shape, the effect would be to draw the flesh upwards and produce, not only painful, but injurious pressure at the end of the stump. Whereas, were that portion of the pelvis, the tuberosity of the ischium, selected for the principal point of resistance, and the remaining part of the bucket left free, the patient would with ease rest the whole weight of his body upon the false leg without in the slightest degree dragging upwards the fleshy part of the stump. In constructing an artificial leg above the knee, therefore, the following principles have to be considered:—first, that the centre of gravity, or that point around which the weight of the patient's body is evenly borne, retains its normal position, and that the relation of the artificial limb to it is the same as that of the normal limb; and secondly, that the articulations or joints are so formed as not only to yield to the leverage exercised by the stump for the purpose of walking, but to maintain the leg in a perpendicular position when the gravity

Fig. 235.



or weight of the artificial limb alone brings them into action.

To discover the precise spot where the centre of gravity falls, let reference be made to the foregoing diagram (Fig. 235), which represents in rough outline the erect position of the human frame.

A dotted line passes down the centre of each leg from the head, showing the line of gravity in each limb when the weight of the body is placed upon either, as in the act of walking. It will be perceived that, from the breadth of the pelvis, these lines there merely approximate slightly, the point for commingling being in the head, which thus forms the apex of a triangle. Now if the skeleton be carefully examined and contrasted with a living person, it will be found that in the pelvis, where the lines in the drawing approach nearer than at their base, the tuberosities of the ischia are situated; and through these points the mechanical lines enabling the figure to be held upright when borne upon one leg pass. It must be understood that the dotted lines simply show the line of gravity of *each* limb,—that which corresponds to the whole body is the dark vertical line drawn from the head to the middle of a base formed by both legs. During the act of walking the line formed by the perpendicular position of the body deviates from the middle of the base just mentioned, and alternately falls within the sole of each foot, forming part of the line marked by dots in the diagram.

From this it will be at once seen that in the construction of the bucket of an artificial leg only one spot, the tuberosity of the ischium, exists where the bearing of the body can be correctly placed. This, if clearly understood by the mechanician, renders the construction of an artificial limb a matter of comparative simplicity.

In illustration of the importance of the foregoing proposition, the following case may be adduced.

Mr. W * * *, aged 18, had lost the right leg by amputation, five inches below the fork or perinæum. Owing to the stump being improperly supported whilst healing, it became contracted laterally and anteriorly, and the patient was unable to bring it in a straight line with the body, or make its extremity touch the opposite leg. The case was further complicated by lumbar curvature of some standing. It is evident that if an artificial leg were attached, on *ordinary* principles, to a stump of the kind described, the foot would be several inches in advance of and apart from the opposite foot.

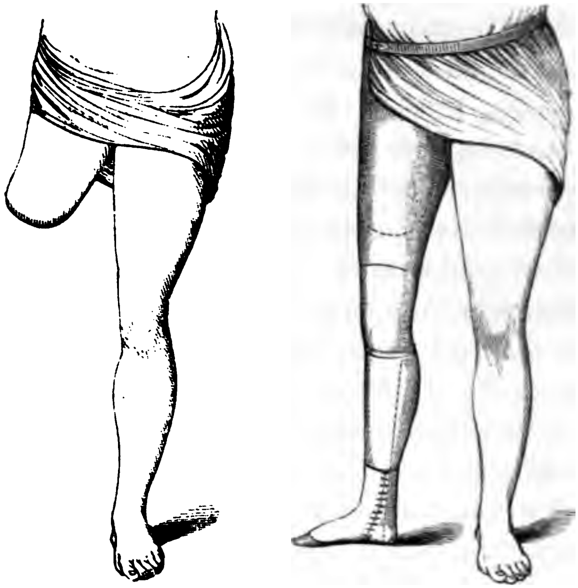
But by acting upon the principles just stated the difficulties of the case were easily overcome. A bucket, fitted to the stump, was made so as to have its sole point of bearing against the tuberosity of the ischium, and the rest of the artificial leg was arranged around a perpendicular line dropped from this point, irrespective of the direction of the stump.

Upon the limb thus constructed being applied, Mr. W * * * stood and walked as perfectly as he would have done had the stump been in a normal condition.

The following diagrams (Fig. 236) represent the form of the stump, and its position when placed within the artificial leg, the dots showing the line taken from the ischium to the ground.

If the human frame be carefully examined, and reference made to the distribution of such muscular masses as constitute the form and shape of the lower extremities, it will be found that the centre of the knee, the centre of the hip, and the centre of the ankle are placed rather more towards the *back* part of the limb than the front, by which the joints obtain a hinge-like

FIG. 236.



motion. This accounts mechanically for powerful muscles, such as those of the calf and thigh being required to bring into action the joints of the leg. In strict obedience to the example set by nature, the mechanician must proceed to construct his artificial articulations, otherwise, upon the weight of the body being placed upon the leg, its centres would yield. If, however, these are scientifically arranged, the weight when added merely serves to increase their stability, as the joints in attempting to bend backwards strengthen themselves, and prevent any anterior yielding. Although nothing in the construction of an artificial leg requires greater care and reflection than the position of the joint centres, it is only during the time the wearer is in a perpendicular posture that they become a matter of importance; as to enable the patient to progress, the artificial limb must become rigid, which can alone be accomplished by an adherence to the rule just laid down, viz., that the articular centres be so placed as to lie behind the line of gravity formed by the weight of the body resting on the artificial surface. To ascertain whether this rule is rightly carried out or not, it is simply necessary to extend a cord from the perinæal edge of the bucket and carry it to the centre of the heel, when the knee-bolt should be three fourths of an inch, and the ankle-bolt half an inch behind the line so formed.

Having correctly established where the joint centres should be, it becomes requisite to distribute their amount of motion. Various means have been devised for the purpose of governing the knee's action, such as the employment of bands of india-rubber or metallic springs, but such methods are rendered *unnecessary* if the mechanical rule of placing the centre a little behind the line of gravity be carefully attended to.

When, however, from shortness of the stump or partial paralysis of its muscles, sufficient vigour cannot be imparted to it to produce anterior action, then a special contrivance becomes necessary. This is best effected in the following manner. A vulcanized india-rubber cord being fixed at one end to the anterior upper edge of the tibial portion of the artificial leg should be reflected over the knee, and passed through a small metal ring like a buckle with its teeth removed; the other end being carried over the edge of bucket and secured to a shoulder strap. The effect of this arrangement is to relieve the stump from the entire backward bearing of the leg when the latter is raised, and transfer to the shoulder band the power of controlling the action of the leg.

Sometimes, however, it happens, notwithstanding that the stump is of proper proportion, that whatever pains the patient takes in learning to gain an easy motion of the knee (whilst walking), his endeavours are in vain; as from a mistaken sense of insecurity the length of swing required to produce a straightening of the knee-joint is nervously neglected, and instead of the body depending upon a firm perpendicular prop, it has nothing but a yielding support to make use of. When this occurs, and it is impossible to make the patient overcome the ill-habit, it is requisite to secure the knee by a bolt, and thus compel a longer stride on the penalty of tripping at every step.* When the wearer requires to bend the knee for the purpose of sitting down, the bolt is easily withdrawn and the free action of the knee immediately secured.

Next in importance to the position of the centres of articulation is the mechanical power governing their action, particularly that of the ankle-joint. Here nature can be followed only at a great distance. A band of vulcanized india-rubber partially imitates muscular action, but in one direction only, viz., that of retraction when once extended, but to create an evenness of force by the *suspension* of the withdrawing power of one set of muscles whilst their antagonists are in use, requires nervous vitality and cannot be communicated to inert substances.

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* The stop or bolt consists of a thin strip of steel passing down the side of the leg, and checking the action of the knee-joint.

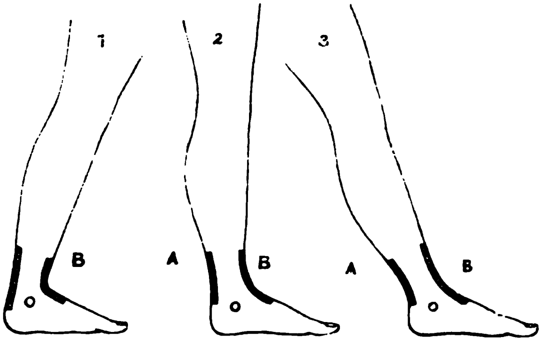
A great objection to vulcanized bands is that either their elasticity diminishes by frequent use, or they break so frequently as to be a continual plague to the patient. This difficulty is obviated by employing a tubular spring, which exercises retractile power when extended, but expansion when compressed, two highly desirable qualities to be combined where equilibrium of centre action has to be maintained.

It is easy to understand that a tubular spring more completely fulfils the requirements of the case than any other mechanism as yet devised, as it produces contraction and elongation with greater evenness of force.

Besides the vulcanized elastic bands and tubular spring, there is another plan occasionally employed. This consists of a horizontal slip of metal placed in the sole of the foot, and fastened to the leg part by a catgut band, the reaction imparting motion to the ankle-joint.

The following diagrams (Fig. 237) are framed to show the position in which tubular ankle-springs should be placed, and their relation to the centre of motion.

FIG. 237.



A, represents the back spring, corresponding in action to the heel tendon; B, the front spring, answering to those tendons uplifting the front of foot; C, the malleoli, or ankle centre.

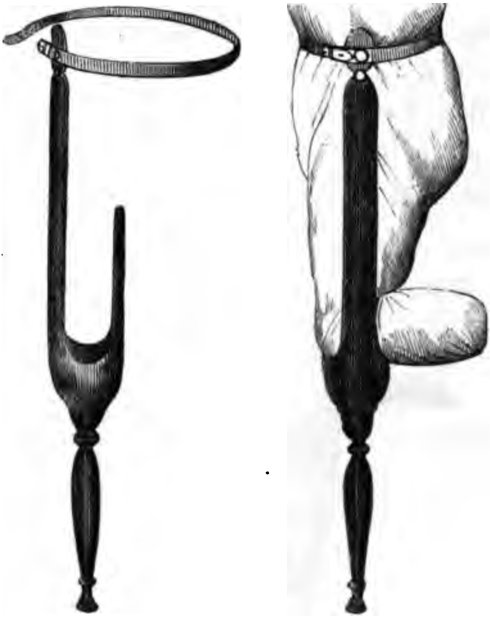
The object of *every* kind of ankle spring is to elevate the toes, whilst the leg is thrown forward in walking, and allow of their falling when the weight of the body is placed upon the heel, thus securing an appearance of natural action. If this were not carefully attended to, the toes would either strike against every trifling inequality on the surface of the ground, or remain fixed at such an angle that when the wearer's body became vertical to the leg, they would turn upwards in a grotesque manner.

The diagrams show the condition of the springs in different postures of the foot and leg.

Having noticed the points requisite to be attended to in the construction of an artificial leg above knee, it is now necessary to discuss the forms of mechanical substitute for a leg amputated below the knee. Of this kind of artificial leg there are several varieties, the simplest being a common wooden or " box leg," such as may be daily seen in Greenwich Park, worn by many of the naval pensioners. The form of apparatus (Fig. 238) consists of a hollow trough to receive the knee, a pin to make up the distance of the trough from the ground, and a shaft to secure it safely to the wearer's body.

Simple as this kind of mechanical substitute is, yet, if properly contrived, there are many conditions in its structure that merit attention. In the first place, the hole into which the pin enters should be bored obliquely, thus widening the base and enabling the patient to stand or walk with greater firmness than if the pin were perpendicular. In addition to this the shaft should be curved a little backwards, so that it may be

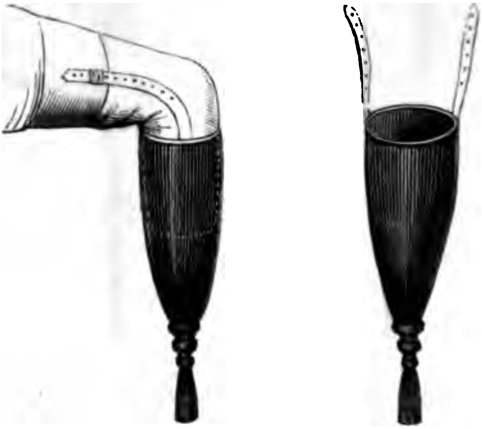
FIG. 238.



fitted with greater perfection to the patient's body. The straps required to fix the leg should also pass over the woodwork, and *not* through it, by which means closer proximity is secured between the leg and the wearer. I have improved the arrangement of this form of leg by affixing a perpendicular hinge to the upper end of the leg shaft, which, when the patient sits down, corresponds to the action of the hip-joint, and prevents the end of the shaft from thrusting backwards, this hitherto having been the greatest objection attached to the use of a common leg.

Another kind of wooden leg below knee consists of a hollow sheath accurately fitting the stump (Fig. 239). This, from its shape, is called a socket leg, its principal advantage being that it preserves and employs the action of the knee-joint, a point too important to be lightly set aside, as it enables the patient to avoid the awkwardness of upsetting every one who, not expecting to find a man's leg projecting

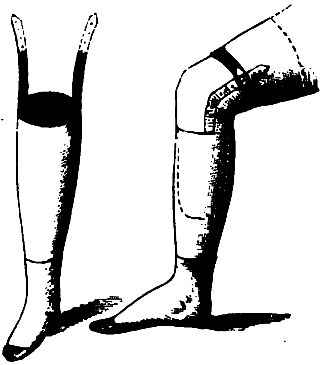
FIG. 239.



many inches beyond his chair, accidentally trips against it.

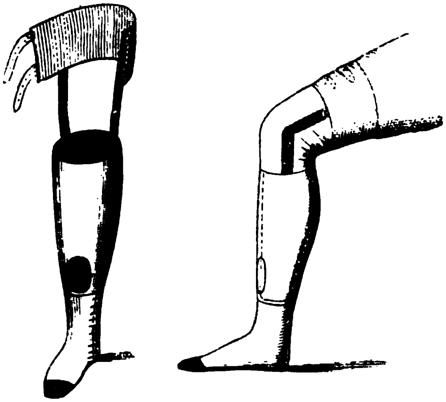
A third kind of artificial leg below knee has many modifications, all more or less dependent upon the length and condition of the stump. It requires great care in its construction. If the stump be one third of the leg in length, and its surface is strong and healthy, then a sheath terminating at its lower extremity in an ankle and toe-joint, and furnished with tubular springs, is the best form (Fig. 240).

FIG. 240.



The sheath is affixed to the leg by a narrow leathern thigh band and two lateral straps. There cannot be any doubt that the best situation for amputation below knee, mechanically considered, is a little beneath the junction of the upper and second third of the leg, as a useful amount of leverage is thus secured without forming a stump so long as to produce abrasion by friction against the inner part of the sheath, as invariably happens if the stump be too long. It has frequently occurred within the writer's experience, that the length of stump has been so great as to necessitate an aperture on the anterior surface of the sheath, as in the annexed diagram (Fig. 241).

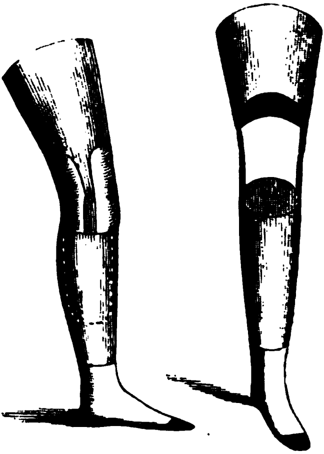
FIG. 241.



Circumstances, however, occasionally arise, requiring the amputation to be above the situation just mentioned. Sometimes but three inches of stump is left. When this occurs the same kind of artificial leg is applied, but instead of attaching it by a simple strap and leathern thigh-band, it becomes requisite to form a solid connection between the thigh and wooden sheath. This is done by two lateral steel uprights, furnished with a stop knee-joint, and attached to the circumference of the thigh by a semicircular band of light metal passing at the back of the leg, about the centre of the thigh. This arrangement not only prevents the artificial leg from being withdrawn from the stump by its weight, but likewise serves to impart motion to the lower leg in walking, the thigh, through the medium of the metal bars, controlling its action.

Sometimes a stump from tenderness will be so extremely sensitive as to destroy all hope of making it a point of bearing. When this is the case (but only then, as so much additional material imparts a certain amount of clumsiness to the leg), a wooden bucket must be appended to the metal lateral uprights in lieu of the thigh-band (Fig. 242). By this means the weight of the body will be received against the tuberosity of the ischium as in amputation above knee. The lateral uprights should be made to slide, thus enabling the patient carefully to adjust the distance between the superior edge of the lower leg sheath and the top of the bucket.

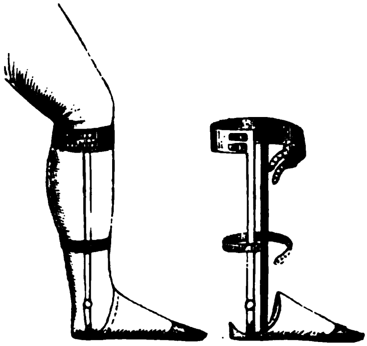
FIG. 242.



Latterly, owing to the advances made in "conservative surgery," many cases have occurred where only the anterior or tarsal portion of the foot has undergone amputation, thus leaving the os calcis or heel for the patient to rest on. This operation, although producing an extremely valuable stump for the purpose intended, is a cause of much difficulty to the mechanician when an artificial foot has to be attached. The mechanical obstacles will be readily understood from a slight description of what has to be contrived.

In the first place, it is necessary to give the form of the anterior portion of the foot, and, having given it, to fix it in such a manner as to prevent pressure against the front of the stump when brought into action by walking. The heel being present, it is evident that whatever is attached must be in contact with it, and when it is remembered that the stump presents a shape like an irregular ball, it will at once be seen that unless the artificial foot is prevented from rising beyond a line horizontal with the ground, the resistance must necessarily fall against the front and tender end of the stump. The plan which I adopt in constructing an apparatus for a stump of this kind is to sink the rounded heel into a very light and thin socket, the groundwork of which is a metal plate, the size and form of the natural sole. Rising laterally, and on both sides from this, are two light metal stems having at the ankle what is called a stop-joint, the reason for which will be obvious when it is stated that it prevents the sole-plate from rising beyond a rectangle, and yet allows the toe part to be pointed downwards when the patient assumes a sitting position (Fig. 243).

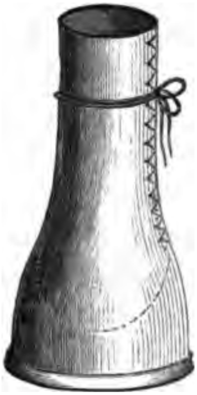
FIG. 243.



Fixed to the front of the sole plate and upon its upper surface, is an artificial two thirds foot, having a toe-joint, and hollowed in that portion which rests against the anterior extremity of stump. The whole is carefully padded and fixed on to the ankle by two narrow straps. Upon the patient attempting to walk with this apparatus he will find the rolling action of the stump checked by the ankle band, which, transferring the resisting force to the sole plate, brings the toe-joint into play, and causes a natural action without the slightest pressure upon the front of the stump. If the end of the latter is at all tender, an air cushion fitted to the heel cavity may be introduced.

This is the only kind of appliance calculated to be of much service in such cases; but, for those patients who do not value appearance and merely seek for such mechanical aid as will assist locomotion, a leathern hood (Fig. 244) bearing no inapt resemblance to an elephant's foot, can easily be made, and the walking rendered good.

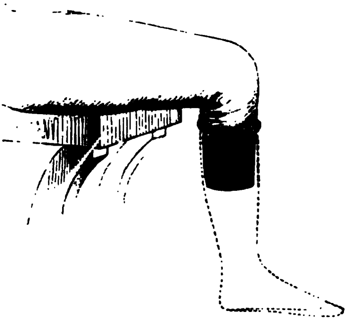
FIG. 244.



As in a leg above knee one particular point is selected to sustain the weight of the patient's body, so in an artificial leg below it becomes a matter of much importance to discover what portion of the interior of the socket is best adapted to receive the resistance of the limb. If the head of the tibia is firmly compressed, very little inconvenience is experienced by the patient, but if the weight of the body be directed against the anterior part of the stump, a straining uneasiness of the flesh against the end of the bone is immediately felt.

It is thus clearly apparent that the distribution of resistance must be over the former surface, and the conformation of the interior of the socket be made in accordance with this rule; as upon this being done very little, if any, uplifting friction can take place against the end of the stump. Having determined this point, the question will undoubtedly arise as to whether a surface consisting of bone with but slight integumentary covering, can be made to sustain *for the necessary lengthened period*, pressure proceeding from a wooden ring, however accurately adjusted to it. This difficulty is, however, easily set at rest by any plan which, without interfering with the special points of bearing embraced in the shape of the sheath, shall give an artificial covering to the hard parts of the knee. This is accomplished by the insertion of a leathern cap carefully lined with a stratum of rather thick chamois skin, and placed between the knee and the inner surface of the wooden leg (Fig. 245), which leathern cap being open at the lower end, does not in the slightest degree interfere with the freedom of the stump, but, on the contrary, rather tends, by holding the muscular covering of the leg firmly together, to encourage any movement within the socket the stump may need for its coolness and comfort.

FIG. 245.



The cap just mentioned is by no means universally adopted, but Mr. Sheldrake, my father, and myself, have successively employed it, and found it of extreme value. I therefore advise its constant use, more especially as every particle of friction takes place between the cap and the wooden sheath, instead of between the latter and the stump, which circumstance would inevitably occur if it were not for the cap.

To show the great amount of difficulty occasionally encountered in having to construct artificial limbs below knee, and the importance of preventing the stump from becoming angularly contracted during the time of healing, the following case may be adduced.

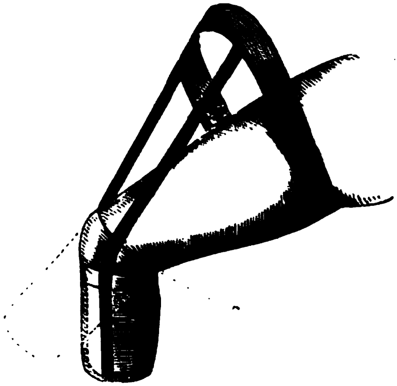
Mr. W * * having whilst in Canada suffered from frost-bite, on account of which amputation of both legs became necessary, the surgeon who performed the operation very wisely determined to save, if possible, the knee-joint, but in so doing left but two inches of stump on one leg and three on the other.

From the shortness of the attaching surface, and, as it would seem, the want of mechanical skill on the part of the Canadian artizans, the laudable attempt of the surgeon to make a useful joint was not heeded, and a couple of artificial legs, with troughs to receive the bent knees, were constructed; the result being that although the patient was enabled to walk, yet upon sitting down the legs projected at right angles before him in a most inconvenient and distressing manner, and the stumps also became angularly contracted.

Upon the patient visiting London, Mr. Fergusson sent him to me, considering it practicable that the stumps which had become firmly contracted at right angles, might by mechanical power be straightened and the mobility of the joint restored, afterwards admitting of a properly constructed pair of artificial legs being applied. Mr. Fergusson suggested the mechanical mode by which this might be accomplished, which consisted of two lateral bars of metal furnished with a hinged centre whose angle could be varied by the insertion of a small screw. At the inferior end of these levers a metal band corresponding to the distance existing between the under part of the knee and the end of the stump was affixed, and in front, passing directly across the centre of the patella, a strong and well padded leathern band joined one upright to the other. When in position the apparatus had the form shown in Fig. 246. Angular variation was obtained by means of a perforated disc and screw at C.

It will at once be seen that upon any attempt

FIG. 246.



being made to bring the lateral uprights close to the thigh in a downward direction, the force of resistance became transferred to the patella strap, and from thence to the metal band at the back of the stump, thus uplifting it. This mode of treatment carefully carried out by Mr. Fergusson, although occupying two or three months, answered eventually in the most perfect manner. The contraction of the stump and immobility of the knee-joints were overcome, artificial legs of the kind described (Fig. 242) adapted, and at this moment the patient walks well and easily, aided merely by a stick, more to prevent an accidental disturbance of his balance by a slippery surface or accidental collision, than for the purpose of helping his walking. No boon could possibly be greater than enabling an individual to walk well under circumstances such as those just detailed, and the case serves to prove what care and ingenuity can accomplish, however difficult the conditions may appear.

Of the more elaborately constructed artificial legs three have obtained especial popularity in this country.

The first of these is of English origin, and, owing to its having been adopted by the late Marquis of Anglesea, is called the Anglesea leg. The second is known by the name of its inventor, and bears the appellation of the Palmer leg. The third was devised by Dr. Bly, of Rochester, New York.

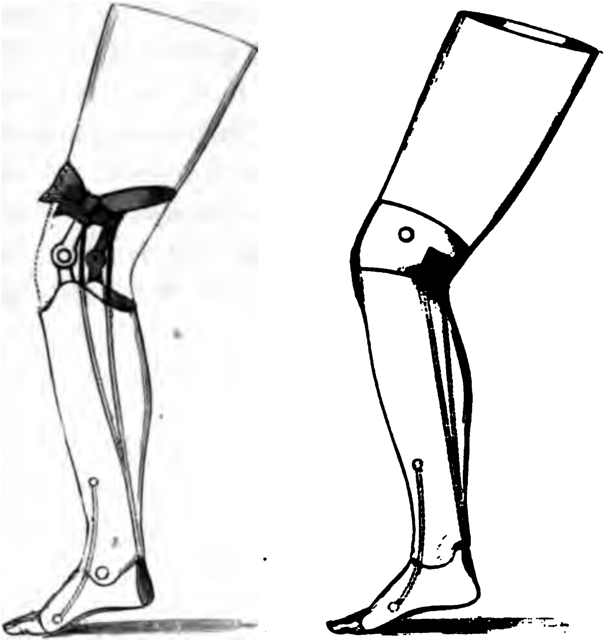
The two former legs possess indisputable merit, and have long been popular, yet neither fulfil entirely the desiderata demanded by those patients who seek to obtain the most perfect representation, in action as well as form, of the human limb. One glaring fault in both these pieces of mechanism is that the natural motion of the ankle-joint exhibited during the act of walking upon an irregular surface is entirely unprovided for, hence the pain and abrasion so frequently experienced by those who use either of these limbs. To explain this more fully, a brief description must be given of the construction of both mechanisms.

The Anglesea Leg.—The Anglesea leg consists of a wooden frame, formed to represent in external shape a human limb, and having ordinary mortise-and-tenon joints for producing the knee and ankle motion. These joints are joined together by steel bolts passing through their centre, and the joints themselves are brought into action by a long piece of catgut fixed at the back of the heel and terminating at the knee, which serves as a representative of the flexor muscles of the knee and extensors of the foot, whilst an india-rubber band fixed in front of the ankle, and attached to a piece of wood in the centre of the calf, effects the purpose of counteracting the catgut cord already mentioned, and flexing the foot upon the leg. An india-rubber band is also fixed in front of the upper part of the leg, to aid in impelling its lower portion forward whilst walking. The upper portion of the wooden frame is hollow, for the purpose of receiving the stump of the patient, and affording attachment between the artificial leg and the body. The original idea of this contrivance was that of representing the action of the muscles of the human limb ; for as the catgut cord is fixed to the back of the knee and terminates in the heel, it serves to extend the foot when the limb is straightened, as in standing; whilst the india-rubber front band, becoming tense, tends to uplift the toes from the ground when the leg is flexed in walking. This idea, though at first sight appearing to be very ingenious, loses all claim to positive merit when the entire absence of lateral motion in the ankle-joint is found to comprise part of its arrangement. Yet, notwithstanding a defect so palpable as the one just named, this artificial leg has been almost the only one hitherto adopted in England.

To render the foregoing description more intelligible two drawings are given, representing an Anglesea leg as arranged for stumps above and below the knee (Fig. 247).

The action of the knee- and ankle-joints is seen to be purely ginglymoid or hinged, so that if the wearer were to tread on any slanting or irregular surface, only a slight edge could possibly rest upon the ground, whilst the stump

FIG. 247.



Below knee. Above knee.

The position of the tendons is shown by dotted lines.

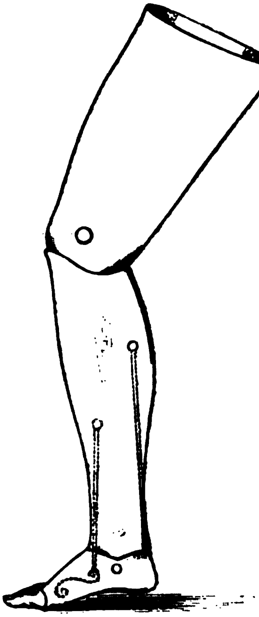
of the patient would be submitted to considerable strain and pressure. By the former contingency great instability is occasioned, and by the latter abrasion of the skin generally results. This highly objectionable condition is entirely attributable to a want of lateral motion in the ankle-joint, as will be seen when Dr. Bly's invention is described.

In addition to other disadvantages, it happens that, owing to the manner in which the catgut is affixed to an Anglesea leg, the toe becomes pointed like a dancing-master's, every time the leg is thrown forward in walking; thus only a small portion of the foot rests upon the ground until the patient's weight brings down the remainder, with generally a heavy thud-like noise. It must be evident to any one who observes the human foot whilst thrown forward in the act of walking, that the heel first touches the ground, whereas in the leg under consideration, the toes come in contact prior to any other portion of the foot. Hence the Anglesea leg has always to be made rather shorter than the natural limb, which necessarily imparts a limping action in walking. This error of construction is entirely avoided in Dr. Bly's leg, by which means the toes readily clear the ground, and all chance of accidentally striking against a stone or other impediment is set aside.

An Anglesea leg also, at its best, presents an extremely ugly external appearance, owing to the wood of which it is composed being left uncovered, except by the stocking of the wearer.

The Palmer Leg.—The Palmer leg (Fig. 248) is constructed with errors somewhat similar to those of the Anglesea, but, instead of a common mortise-joint forming the ankle movement, a peculiar adaptation is made by rendering the foot

FIG. 248.



Above knee.

part hollow, and placing the solid part of the leg within its cavity, thus producing a neater external appearance, although at the same time greatly weakening the joint itself. For as the leg is held in place at the ankle by a metal bolt passing through the centre of the joint, and as it has no other check but the catgut band mentioned in the arrangement of the Anglesea leg, it is evident that, upon any stretching or fracture of the catgut occurring, the front of the instep must become violently torn away, and the patient permitted to fall forward, most probably to his serious injury. The method by which action is given to the ankle is also by means of a catgut cord at the back of the leg, and an india-rubber or wire spring in front, the former representing the flexor, the latter the extensor muscles. From the lightness of the Palmer leg and the ease of walking with it, it has long superseded the Anglesea leg in America.

Dr. Bly's Leg.—The faults apparent in both the Anglesea and Palmer legs have been entirely overcome by an ingenious piece of mechanism invented and patented by Dr. Bly, of America. He having the advantage of accurate anatomical knowledge, and carefully examining the human leg by frequent dissections, devised an exact imitation of the action of the ankle-joint, obtaining free lateral rotation and antero-posterior movements, thus securing those conditions which are observed in the formation of the human foot and ankle. Patients who have used either an Anglesea or Palmer leg must frequently have experienced the disagreeable sensation which results from the stump being harshly pressed by the sides of the artificial receptacle on standing upon any uneven surface; for as the vertical centre of the stump should always coincide with that of the artificial limb when the patient stands or walks, it necessarily follows that any circumstance which has a tendency to disturb the coincidence between the line of the stump and the line of the artificial limb must materially influence the natural gait of the patient, in addition to imparting unequal pressure to that portion of the stump which receives support from the surface of the sheath in which it is placed.

When a human being performs the act of walking, he sustains his body in equilibrium almost entirely through the mobility of the ankle-joints. It is true that walking can be accomplished where the ankle-joints are anchylosed, but a very lame and ungraceful gait is the consequence, which is but slightly diminished on mere antero-posterior motion being restored to the ankle. It may thus be easily proved that upon the yielding of the lateral ligaments of the ankle-joint in walking almost exclusively depends the rapidity with which brisk walkers are enabled to perform their pedestrian exercise. But so important an element in the construction of an artificial limb as the lateral motion of the ankle was never adopted until Dr. Bly so successfully demonstrated its necessity in the invention of his American leg.

The joints in this leg are made without iron or any kind of metal, therefore the leg is extremely light, much lighter than any other. The liability of metallic joints to rattle and make a noise, after the leg has been worn a short time, is well known, and the annoyance which it causes the wearer at every step is also well known. Now, as there is no metal about the joints in this leg, there is no noise. The ankle-joint is formed by a ball of polished ivory, plying in a socket of vulcanized india rubber.

This joint accomplishes the great object which artificial leg makers have hitherto sought for in vain, viz., it admits of motion in all directions like the natural ankle-joint, and thereby allows the artificial foot to accommodate itself to the inequalities of the surface, the same as the natural foot. This enables the wearers of Dr. Bly's artificial leg to walk so well that the want of a limb is not even suspected, much less detected.

Furthermore, this is a form of joint that requires no oil; a fact of no little importance, as those persons will testify who have worn legs with metallic joints, and who have been obliged to carry pocket oil-cans.

In the places corresponding to those occupied by the muscles of the natural leg are placed rubber springs with catgut cords of sufficient strength, extending downward in place of the natural tendons; and it is astonishing how well the action of these springs imitate the natural muscles.

The springs are made of railroad-car spring rubber, and act by compression, therefore it is not possible to overtax or break them. This will be appreciated by those who have worn legs with metallic springs, especially by those who have worn the Anglesea leg.

The power and action of all the springs in this leg are regulated simply by turning a nut; so that the wearer may adjust the tension to suit his own gait with the greatest facility.

Then, instead of the mechanical motions given to a limb by metallic springs, the rubber springs impart easy uniform motions to the limb, giving it, when in use, a remarkable life-like appearance.

In walking, when the weight of the body rests upon the ball of the foot, the spring representing the gastrocnemius and soleus muscles is firmly compressed, and when the weight of the body is thrown forward on to the other foot the spring rises and carries the foot forward to its place, with very little effort of the wearer.

In ordinary walking, with the toes turned outward, the foot, like the natural one, is flexed diagonally, or in the line of motion, which makes a step graceful. Artificial legs made heretofore roll the foot to compensate for this diagonal flexion, hence the uneven gait so often seen.

If the foot is turned out sidewise to brace the body or for work at a bench, as in many kinds of mechanical labour, the ankle-joint flexes laterally and the foot remains flat on the ground, and gives a firm base of support, which is of great importance in all kinds of labour.

Moreover, when walking, if one side of the foot happens to be placed on a stone or elevation, or into a hole, the mobility of the ankle-joint allows the foot to yield just enough to accommodate itself to the inequality, and thereby prevent stumbling or falling, which necessarily takes place more or less with all artificial legs which do not admit of lateral and diagonal motion at the ankle-joint.

The knee-joint, for amputations above the knee, has no side or lateral motion, because there is none in the natural knee. The joint is constructed in such a manner that no bushing is ever required; consequently, the annoyance and expense of sending the legs to the maker to have the joints bushed every now and then, to keep them tight, is entirely avoided. The joint is so arranged that the wearer may tighten it in a moment whenever he chooses.

The knee-joint is operated on by a spring similar to those already described. Its motions are limited and controlled by two cords which take the place of the crucial ligaments of the natural knee-joint; consequently, there is no unpleasant jar caused by any solid parts coming in contact.

For amputations below the knee no artificial knee is required, but there is a jointed steel strap on each side of the knee, which supports the leather lacer. In the construction of these straps there is another neat little invention, which, like the rest, takes nature for its guide.

By laying a femur (thigh-bone) on paper, and drawing a line on each side, the exact curve of the lower end of the bone is obtained. To the jointed extremities of the straps the same curve is given, consequently they work in harmony with the natural joint, and conform to the contour of the knee, which allows the dress to remain smooth when sitting with the knee flexed.

The square or angular straps, used by all other makers, make a very bad appearance when the wearer is sitting, and are ugly uncouth things, to say the least. They show the necessity of taking nature for a guide in all things pertaining to artificial legs.

The advantages of Dr. Bly's artificial leg, generally summed up, are these:

1st. Adaptation to all amputations, either above or below the knee.

2nd. Rotation and lateral action of the ankle-joint, thus affording a kind of ball-and-socket motion, whereby the patient can rotate his limb without engendering the least friction against the sides of the stump.

3rd. Power on the part of the patient to walk with ease upon any surface, however irregular, as, owing to the motion of the ankle-joint, the sole of the foot readily accommodates itself to the unevenness of the ground, which is an advantage never before possessed by any artificial limb.

4th. The ankle-joint is rendered perfectly indestructible by ordinary wear, owing to its centre being composed of a glass ball resting in a cup of vulcanite; thus it never gets out of repair, as the Anglesea leg but too frequently does, and the original cost is almost the only one the patient incurs.

5th. The action of the ankle-joint is created by five tendons, arranged in accordance with the position assigned to them in a natural leg. These tendons are capable of being rendered tight or loose in a few instants, so that the wearer of the leg has the power of adjusting with precision the exact degree of tension from which he finds the greatest comfort in walking, and also of giving the foot any position most pleasing to the eye.

6th. There is a self-acting spring in the knee-joint, urging the leg forward in walking and imparting automatic motion, thus avoiding the least trouble to the patient, who finds the leg literally, and not metaphorically, walk by itself.

7th. The whole is covered with a beautiful flesh-coloured enamel, thus avoiding the clumsy appearance of the wood as is always found in an Anglesea leg, and admitting of its being washed with soap and water, like the human skin.

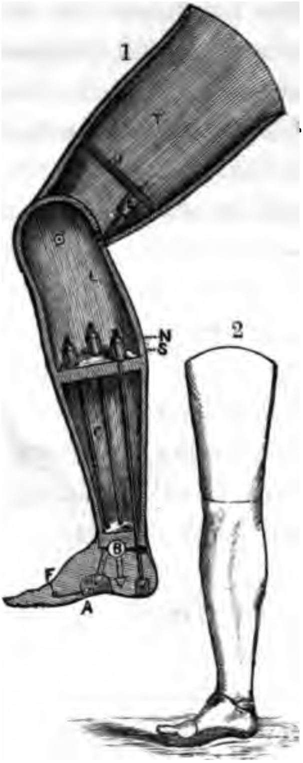
8th. At the knee-joint there is a mechanical arrangement, representing the crucial ligaments, and affording natural action to that articulation by which all shock to the stump in walking is avoided.

The following drawings (Figs. 249, 250, 251), and description, extracted from the patent specification, is perhaps the readiest method of explaining the construction of this new form of artificial leg, and its advantages.

Fig. 249, 1, is a section of the leg.

The ankle-joint is formed by a ball (B) of polished ivory, which admits of every motion that the natural ankle does, without an exception.

FIG. 249.



The cords (C) have the position and imitate the functions of the natural tendons. Only three are shown in full, but the ends of all are seen in Fig. 250, 1.

(S) marks three of the five rubber springs which take the place of the muscles of the natural leg.

(N) shows the position of the nuts, by which the tension of the cords and springs are regulated to suit the wearer.

(E) is the spring which acts upon the knee-joint.

Fig. 250, 2, is a posterior view of the leg and thigh; the thigh in section—showing the knee-cords (K) which take the place of the crucial ligaments of the natural knee.

Fig. 251, 1, shows the curved joints (X) on either side of the knee, as constructed by Dr. Bly, for amputations below the knee. The curve corresponds with the natural knee, and allows the dress to set smoothly.

And fig. 251, 2, shows the joints (T) for the same purpose, as constructed by other makers.

Fig. 250, 3. The right leg of this figure shows one of Dr. Bly's artificial legs, worn by a mechanic, and flexed laterally at the ankle-joint, the same as a natural leg. The leg assumes every position of the natural leg with facility.

Fig. 249, 2, represents the ankle-joint flexed diagonally, as is often the case when one side of the foot happens to be placed on a small stone or other obstacle.

FIG. 250.

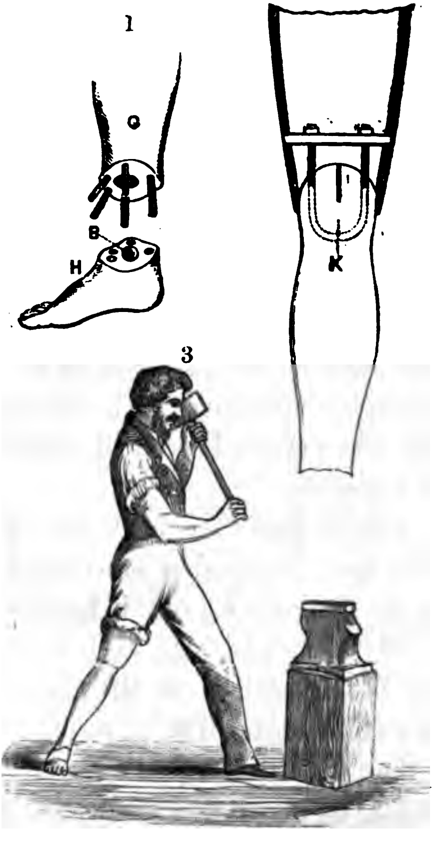
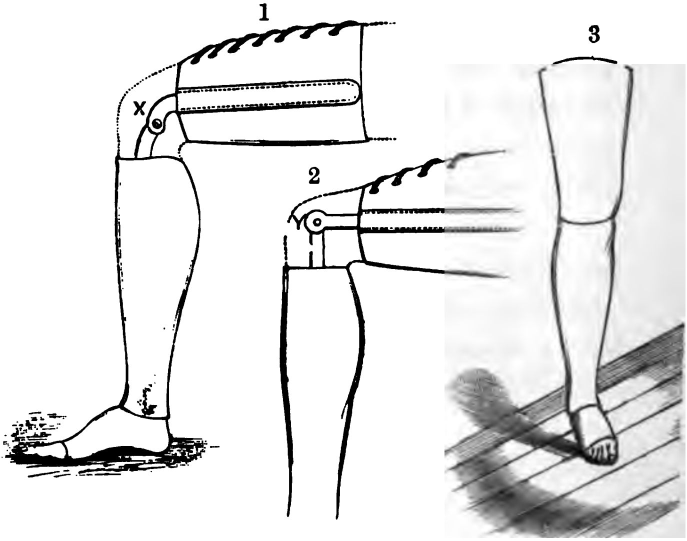


Fig. 251, 3, shows the action of the ankle-joint when walking on the side of a hill or on an inclined plane, the foot accommodating itself to the surface like the natural foot.

Fig. 251.



With these observations on the construction of artificial legs this work ends. It is but an outline of a great subject. If it should fail in securing for mechanical therapeutics that recognition as a science and an art which I am anxious to bring about; if, indeed, I am premature in seeking for ORTHOPRAXY a recognised place among the different branches of Medicine, I would at least hope that these pages will tend to awaken such interest in the subject as will promote that end for which they were written and which I so ardently desire.

APPENDIX.

I.

The following paragraph was accidentally omitted from the chapter on *Deficiencies of the Head and Neck* (p. 116).

Deficiency of Cheek.—The cheek is sometimes seriously injured by bullet wounds, the destruction of tissue being so great that an unsightly and disagreeable fissure is left, interfering both with the mastication of food and the imbibition of liquids. A case of this kind, which occurred during the Crimean War, came under the notice of Her Majesty at the time of one of her visits to the military hospitals. I had the honour to receive from Her Majesty personally a command to relieve mechanically, if it were practicable, the evil from which the wounded man suffered. I contrived to effect this object by forming an artificial cheek of silver, which was carefully fitted above the fissure. This, when fixed in position and painted to represent the natural flesh, largely removed the extreme disfigurement from which the unfortunate man suffered, and enabled him to masticate his food and take fluids with much greater comfort.

The course pursued in this case is that which would meet the majority of cases of a similar character.

II.

Case of Equino-valgus of twenty-six years' standing: —tenotomy:—mechanical treatment:—cure.

The most difficult, but at the same time, perhaps, the most interesting cases which Orthopraxy has to encounter, are those where the age of the patient or the long duration of the case seems to present an insurmountable obstacle to successful treatment. The following case is instructive as showing what good may sometimes be effected in the least promising cases by persistent effort.

A young lady of 28 years of age was placed under my care for equino-valgus of the right foot, of twenty-six years' standing. When the patient stood erect there was at least five inches' difference between the heel and the ground. The arch of the foot was obliterated, and the whole leg much wasted. There was little difference in length between the two limbs, and the dimensions of the thighs were about equal, but the right thigh was more flaccid than the left. Not a trace of voluntary action remained in the extensor muscles of the right leg; but it was ascertained that each muscle responded, although exceedingly slightly, to the electric current.

The history of the varied treatment to which this case had been subjected for many years almost deterred me from undertaking its management. It seemed as if the resources of mechanical therapeutics had been exhausted in futile efforts to obtain relief. I resolved, however, to make another attempt, and for this purpose the patient took up her residence in my house. In the first place I consulted my friend Mr. Nunn upon the propriety of dividing the tendo Achillis. He agreed with me on the necessity for this step, and performed the operation. Five days afterwards the heel had descended two inches. I then adopted a modification of Scarpa's shoe, by means of which the descent of the heel could be augmented, and the abduction of the foot rectified. By the aid of this apparatus the foot was very gradually brought into its normal position.

On this being effected I sought to develop the action of the wasted extensor muscles by electricity. For this purpose I secured the assistance of my friend Mr. Radcliffe. He applied an interrupted current to the extensors thrice weekly over two months, and with excellent results. The extensors slowly gained power, and some degree of voluntary control was obtained over them. At the same time, under the influence of electricity, daily frictions with camphorated oil, and spouting with salt and water every other day, the leg rapidly increased in bulk.

In the mean time the patient had been able to move about on crutches, and to some extent without their assistance, but on standing without support considerable pain was experienced in the fore part of the ankle. This pain increased and became troublesome, and it was thought best to intermit the frictions and electricity, and fix the ankle firmly in gutta-percha splints. On this being done the pain on standing gradually diminished.

It is now five months since the treatment commenced, and the present condition of the patient, she having returned to her own home, is as follows:—She stands without perceptible deformity. She walks without aid, and with but a slight limp. A walk of three miles only fatigues the limb, without causing pain. The nutrition of the leg, measured by bulk, is equal to that of the opposite limb. The power regained in the extensor muscles by electricity is retained and increasing. The arch of the foot is gradually being restored, and, with the exception of a slight distortion of the great toe, the foot is almost equal in comeliness to the opposite foot. The ankle, as a matter of precaution, is still kept in the gutta-percha splints, but these will be cast aside in a few weeks; and although care will still be required to foster the power regained in the extensor muscles, the cure is to all intents and purposes complete.

III.

Arrested Development in the Lower Limb.—Occasionally cases are found where, owing to an arrest of osseous development, the lower extremities are much reduced in proportion; thus rendering the patient dwarf-like in stature.

Fortunately mechanical agency can remedy this defect, and place the patient at once on the ordinary standard of height. The plan for effecting this object consists of two artificial feet placed twelve or fourteen inches below the natural members. These are attached to the legs by means of metallic rods jointed at the knee and ankle, whilst the natural feet are received in boots forming part of the apparatus.

With this device a dwarf may be made to assume the proportions of an ordinary person, whilst the artificial feet are so perfectly arranged as to admit of the patient walking with perfect ease.

Few know the sufferings experienced by sensitive women on finding themselves the objects for ridicule on account of their lessened stature, or how much that feeling is diminished by a knowledge of the mechanical means which exist for its amelioration.

IV.

Spinal Pain.—In a recent number of the 'Lancet,' my friend Dr. Dick has drawn attention to the prevalence of vertebral pain in cases of miscalled lateral curvature.

The explanation is that the vertebral column never yields in a purely lateral direction except in cases of pleuritic adhesion. In all other circumstances the spine becomes rotated on its vertical axis, and pain from medullary pressure is the attendant evil. Dr. Dick proposes pressure against the prominent portions of the lumbar and dorsal vertebræ, by means of oblong plates so arranged as to act with mechanical force in an antero-superior direction. This principle was expounded by myself seven years ago, after reading a description of Dr. Mantell's case, and I invented a rotative apparatus for the purpose of rectifying the peculiar conditions there set forth. Dr. Dick has displayed considerable ingenuity in working the same field, and the results obtained appear very satisfactory. The form of apparatus he adopts consists of a pelvic band with two lateral uprights, at the inferior extremity of which a clavicular band, similar to that shown at Fig. 125, is adopted. On either side of the spine there are vertical rods connecting the clavicular and pelvic bands posteriorly, and giving attachment to two oblong plates, one resting on the lumbar, the other on the dorsal arcs. These plates are acted upon by a small piece of mechanism in such a manner as to admit of their being tightened at will; and there is also a webbing band passing over the lumbar and dorsal costal surfaces, and affording slight lateral support to those regions. The whole plan displays great ingenuity.

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